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GEOLOGIC STRUCTURES IN THE ETHIOPIAN REGION OF EAST AFRICA*

By M. HALL TAYLOR†

East Africa consists of broad domal uplifts separated by basin structures, across which extend a series of rift valleys, running for more than 3,000 miles from the vicinity of the Zambesi river in south central Africa to the Jordan valley of Asia Minor in the north. This paper will examine the Ethiopian and adjacent areas, the region studied in the field by the writer.

Physiographically, Ethiopia and the neighboring Somaliland country to the east may be divided into three major provinces, as shown in FIGURE 1. These divisions are (1) the Ethiopian massif, (2) the rift valley graben, and (3) the Somali plateau.

On the northwest is the Ethiopian massif, a rugged mountainous area with heavy rainfall and deep river gorges. Granites, gneisses, and schists, definitely of pre-Mesozoic and probably of pre-Cambrian age, form the basement rocks of this region, and are exposed in the bottoms of some gorges, as are also comparatively thin sequences of the overlying Mesozoic sediments. Most of this region, however, is covered by thousands of feet of basalts and associated volcanics of Cenozoic age, which have been extruded from volcanoes and fissures associated with the rift valley. Within this massif are downfaulted basins which appear to be genetically related to the much larger rift valley structures located to the south and east. Lake Tana, source of the Blue Nile, lies in such a depression, the outlet of which has been partially blocked by Pleistocene and Recent lava flows.

Southeast of this mountainous region, and extending transversely across Ethiopia in a northeast-southwest direction is a portion of the African rift valley system. In the southwest at Lake Rudolf in northern Kenya, this graben bifurcates, one portion continuing northward for a short way and then disappearing in the basalts of southwestern Ethiopia, while the other arm extends northeastward to join with the Red Sea graben. It thus forms a major tectonic feature across Ethiopia. Fumaroles, hot springs, and unweathered lava flows within the graben attest to the comparative recency of volcanic activity in the area.

East and south of this rift valley, and extending to the shores of the Indian ocean, is the Somali plateau, an area of more than a quarter million square miles covered largely by Mesozoic and Cenozoic sandstones, shales, limestones, and evaporites. Faults separate this plateau from the rift graben to the northwest, the crest of the plateau rising more than 3,000 feet above the graben floor. Deformation diminishes to the southeast, as does also evidence of former volcanic activity, though lava flows and sills occur more than 300 miles southeast of the rift valley graben.

Underlying the Somali plateau and exposed in places along the uplifted borders of the graben are basement rocks: granites, diorites and schists, cut by aplite, pegmatite, and lamprophyre dikes. Their ages, as in the massif, are uncertain. They are definitely pre-Mesozoic, and probably pre-Cambrian. Above these is a thick basal sand. It is arkosic in places and represents the first deposit of transgressive sea which covered much of east Africa in the early and middle Mesozoic. In Eritrea it is known as the Adigrat sandstone, and in places is several hundred feet thick.

Above this basal sand are upper Jurassic beds, mainly Kimmeridgian in age, containing primarily marls and limestones with considerable shale and some gypsum in the middle portions. Some of the marl layers contain much clay and are quite impure, yet alternate with almost pure limestones. Fossils are abundant at several horizons, *belemnites* for instance occurring by the thousands in some of the shales.

These Jurassic sediments were probably deposited in a shallow neritic environment in which source sediments came from distant cratonic elements. The presence of some evaporites suggests that arid conditions prevailed over the shallow lakes and lagoons while the sediments were accumulating.

A thick sequence of gypsum with some interbedded limestone layers, comparatively non-fossiliferous, marks the transition from Jurassic (Port-

* This paper, illustrated with lantern slides, was presented at the meeting of the Section on February 4, 1952.

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landian) to Cretaceous (Barremian) strata. The gypsiferous beds are of lensing nature and exhibit considerable lateral variation, as is to be expected in such deposits. They indicate that periods of considerable desiccation prevailed in east Africa in late Jurassic and early Cretaceous time.

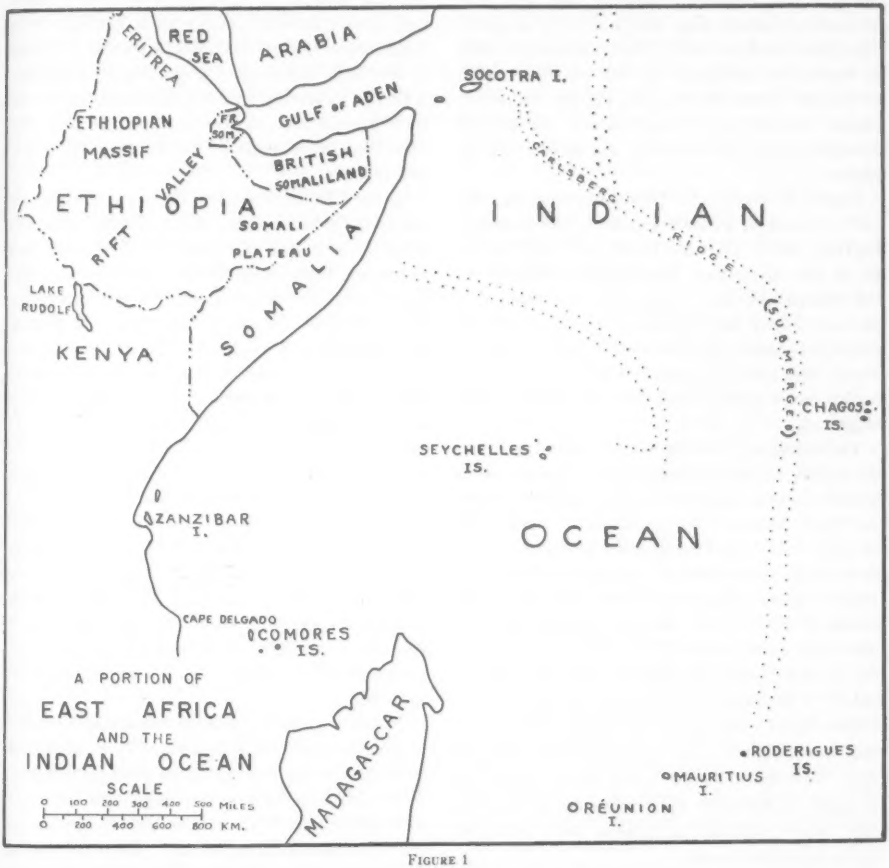

FIGURE 1

Overlying these gypsiferous strata are limestones with some shaly intercalations. Near the top the limestones become quite cherty, and also contain a few thin gypsiferous layers. These beds range from lower to middle Cretaceous in age, and indicate a resumption of limestone deposition in a shallow water or cratonic shelf environment.

Another sequence of gypsum, unfossiliferous but placed in the upper middle Cretaceous by fossil-bearing strata above and below it, overlies these limestone beds, and indicates that aridity again prevailed over much of this portion of Africa. Correlations with other areas have not been published, but gypsiferous sequences occur in Arabia in approximately this portion of the geologic column, and it is likely that the conditions of aridity were sufficiently widespread at this time to influence sedimentation outside the borders of east Africa.

Another limestone sequence, upper Cretaceous in age, overlies the gypsum, and grades upward into a sandstone which marks the boundary between Mesozoic and Cenozoic beds. This sand directly overlies several older formations in different places, and apparently was derived from uplifted areas on the periphery of the basin of deposition which existed in east Africa in the upper Mesozoic. It

may reflect erosion of areas uplifted during early stages in the formation of the rift valley graben.

Eocene and younger Cenozoic limestones, shales, and evaporite deposits form the surface rocks where Mesozoic beds are not exposed. Most of the strata dip gently to the south or east, and thicken in the same direction. The source of Mesozoic sediments may have lain in the area now filled by the Indian ocean. Such a situation would be somewhat analogous to that which prevailed in eastern North America during the Paleozoic, where a sedimentary source east of the present coastline is needed to explain the record now revealed.

Those who espouse the hypothesis of continental drift can suggest a handy source for the sediment. DuToit (1937) pictures India and Madagascar fitted into the region immediately southeast of the Somali plateau. That such land masses, if present, might have provided source rocks for sediments cannot be questioned, but it will be shown later that the geology of these masses raises doubts as to their former presence in the region suggested.

The stratigraphy of the Somali plateau indicates the region was a subsiding basin of deposition, an intracratonic geosyncline on the African craton, in upper Mesozoic time. Deposits within the structure are neither comparable in thickness with those of the great Tethyan orthogeosyncline of the Mediterranean region nor do they have the linear extent of that trough. Rather, the basin appears somewhat comparable to the Michigan basin of the United States, though the deposits are primarily of Mesozoic and not Paleozoic age, and intrusive lavas occur at several places. The basin may have originally had a much greater areal extent, possibly including areas as far north as southern Eritrea and the headwaters of the Blue Nile, where outcrops of Jurassic and Cretaceous strata have been noted.

Formation of rift valley structures has been ascribed by various investigators to both tensional and compressive forces. Some geologists, among them Gregory, Cloos, and Busk (1945), have considered the troughs the result of downdropping of the earth's crust through tension, much as the keystone of an arch collapses if the supporting sides give way. Others, including Wayland, Bullard, and Willis (1936), have believed that horizontal compressive forces have caused blocks of the earth's crust to override and depress the elongate central troughs, and to hold them down through pressure from the sides.

Evidence can be cited supporting either view. Observers working among the volcanics of central Africa generally have favored compression, while others, such as Tromp (1950), who have worked near the Red Sea or other areas of thick sedimentary cover, have favored tension resulting from updoming. Dixey (1945) has cautioned that some of the fault valleys now geographically associated with rift structures antedate rift faulting, though they formed after Karoo (early Mesozoic) sedimentation, as a result (in most instances) of normal faulting.

In the Ethiopian section of the rift graben near Dire Dawa, fault planes dip vertically or have a small hade in the direction of the graben, thus suggesting that tensional forces were present during formation. Another, though not conclusive, bit of evidence supports this view. If grabens are downdropped blocks resulting from tension in the earth's crust, and are bounded by faults which dip toward the graben, the material displaced within the depths of the earth will have occupied a smaller volume than the space vacated at the earth's surface by the downdropping of the block. Conversely, if downdropped blocks are bounded by faults which dip away from the central graben as a result of overthrusting, the material displaced at depth will be greater than the space vacated at the surface. If it is assumed that the displaced material is ejected to the surface a comparison of the volume of such material with the space displaced at the surface by faulting should prove interesting.

Accurate quantitative evaluations based on these assumptions are uncertain since it is impossible to determine the amount of material carried away by erosion, and furthermore there is no proof that all displaced material has come to the earth's surface without change of volume. But it is interesting to note that volcanic ejecta apparently comprise only a small percent of the space vacated at the surface as a result of faulting. Displacement effected within a zone of compensation some distance below the earth's surface, however, might be spread over such wide areas as to negate any conclusions deduced by this reasoning.

Still another bit of evidence suggests lack of compressional forces. Two thick evaporite sequences, largely gypsum, occur in Jurassic and Cretaceous beds, and additional gypsum layers appear higher in the section. Gypsum is notably

weak in resistance to compressional forces. If the region underwent compression sufficient to override great blocks of the earth's crust, it appears likely that there would have been extensive deformation of the gypsum beds near the graben walls, yet such has not been observed.

Negative gravity anomalies have been reported in some of the rift valleys, though not in areas of extensive volcanic activity, and have given rise to the suggestion by some that such blocks must be held down by horizontally-directed pressure from the sides, else they would tend to rise. Deposits of buried volcanic ash from explosive eruptions, however, or diatomaceous earth formed in temporary lakes, or other substances may cause considerable deviations from the calculated value of gravity, and thus cause anomalies which do not accurately reflect subsurface conditions.

The ages of the rift valley structures are difficult to determine because the faults commonly occur among volcanics which lack time horizons, or among pre-Cambrian igneous and metamorphic rocks. In some places in eastern Ethiopia, upper Mesozoic strata are cut off by the graben, while Eocene beds apparently were not deposited, suggesting an origin in earliest Cenozoic time.

Movements probably began at different times in different areas but have continued to the present, as is evidenced by displacements within Pleistocene and later strata, as well as by earthquake and volcanic activity in portions of the region today. Some lava flows in eastern Ethiopia, such as the one near Awareh, appear completely fresh, and farther south in central Africa there are active volcanoes. Volcanism has been contemporaneous with the faulting and folding, probably dating back at least to the Oligocene in Ethiopia.

Some rift structures originated as early as Eocene time. Tromp (1950) has reported that in the Gulf of Suez area, where limited information has become available from deep test wells drilled by oil companies, lower Eocene beds occur both inside and in closely adjacent areas outside of the graben, whereas upper Eocene marine strata are found only within the graben, thus suggesting initiation of movement about the middle Eocene. Facies changes, insofar as known at present, confirm this view.

In the Somaliland region the presence of Eocene sands lying unconformably on various Cretaceous formations may reflect initial movements in the graben about the end of the Cretaceous. As with many faulted structures the first movements here may have long preceded the times of most pronounced movements, which came in the middle and later Cenozoic.

Busk (1946) has noted that, associated with rift valleys, there are several large-sized uplifted triangular blocks of the earth's crust with apices pointing southward and with included strata dipping northward. Examples included the Sinai peninsula lying between the Gulf and Suez and the Gulf of Aquaba, with an aggregate throw at its south end exceeding 6,000 feet, and the Mbeya mountain block lying between the Rukwa and Ruaha troughs in Tanganyika north of Lake Nyassa, with a smaller throw. He suggests there may be some connection between such structures and southward pointing apices of continents, which in turn may be related to the distribution of lands on the earth's surface.

Such theories, though interesting, are countered by noting that the configurations of some fault blocks do not conform to this pattern. For example, the southernmost corner of Arabia points southwest, not south. The northeast corner of Italian Somaliland juts northeastward into the Indian Ocean, and the beds dip generally to the west and southwest, yet the block is bounded by faults. East of Addis Ababa in Ethiopia a small angular block points southeast. In southern Ethiopia, however, west of Lake Stephanie and northeast of Lake Rudolf there is a triangular block which does point south. Such examples are interesting, but their significance must await a better understanding of the tectonics of rift valley structures.

There is some indication that troughs similar to those of the rift valleys continue beneath the waters of the Indian ocean. Fault scarps bound the Gulf of Aden for its 600 mile length, causing relief exceeding 8,000 feet between the surface of the gulf and the highlands of southern Arabia. This is somewhat reduced in British Somaliland, to the south, though here several scarps with a total height of more than a mile overlook the lowlands of the coast. About 150 miles east of the tip of Africa, Socotra island rises almost a mile above the Indian ocean. On it are exposed some granites, which probably are genetically related to the granites found along the fault scarps of British Somaliland. Thus it appears likely that the graben structures of East Africa continue at least to this island.

Beyond Socotra island any possible fault troughs or scarps lie below sea level. Wiseman and Sewell (1937) have reported, however, that the Carlsberg

ridge, which rises some two miles above the floor of the Indian Ocean and extends from the vicinity of Socotra island southeast and south at least to the Chagos archipelago, actually comprises two ridges separated by a trough between one-half and one mile deep, and may thus be a counterpart of the rift valley structures in Africa, 1,500 miles to the west.

A second submerged ridge, without any reported central trough, begins near the African coast at about 4° N. latitude and extends southeastward, paralleling the Carlsberg ridge, and bisecting the Somali basin, which is that portion of the Indian Ocean floor lying southwest of the Carlsberg ridge. This second ridge rises over a mile above the globigerina covered floor of the basin, whose depth exceeds three miles. It may merge at its southeastern end with the Seychelles bank, an arcuate area more than 1,000 miles long which rises from the ocean floor north and east of Madagascar, and is marked on the north by the granite bearing Seychelles islands and on the south by Réunion island.

The merits of the hypothesis of continental drift have long been argued among geologists. Some, including many in North America and Europe, have strongly opposed the concept that major continental masses have in past geologic ages moved about over the earth's surface. Others, particularly men who have worked in Africa, have supported the view, and some have even suggested that the rift valleys represent an early stage in the splitting up of the African continent. Van der Gracht (1928) aptly observed that views on drift will undergo many changes in the years ahead as new evidence becomes available, just as in the past new evidence has caused alteration of ideas on Alpine nappe structures and other great geological problems.

Consideration of continental drift commonly involves comparison of widely scattered observations, but within the limited areal scope of this paper a few points may be noted which bear on the problem.

There appears to be no evidence in the Ethiopia-Somaliland area of wide separation of beds which were formerly contiguous across what are now rift valley fault zones, as would be expected if such breaks represent the initial stages in the drifting apart of large crustal blocks. Instead it appears likely the faults have resulted from tensional breaks in domed or upwarped areas.

In the Gondwanaland continent, as outlined by DuToit (1937) or modified by King (1950), Madagascar is placed about 800 miles northwest of its present position, in the coastline re-entrant now occupied by Zanzibar. India lies just to the east, with its apex off the southern tip of Madagascar, at a point which today is about east of Cape Delgado. Does geological evidence support such hypotheses?

Madagascar consists principally of ancient crystallines and igneous rocks except in its western part where westward dipping Triassic, Jurassic, and Cretaceous strata occur. These might have been deposited as a contiguous part of the Mesozoic intracratonic geosyncline of the Somali plateau, but since there are scattered Mesozoic sedimentary rocks on the African mainland west of Madagascar's present position, it might be argued that the island was at one time more likely to have been connected with these strata than with the beds far to the northwest.

Even though it may be reasonable to place Madagascar near the Somali plateau on the basis of stratigraphic evidence, some difficulty develops with India. The extensive Cretaceous Deccan basalts of peninsular India have no counterpart in Madagascar or the Somali plateau region. Furthermore, movement of India from its postulated to its present position would require crossing of the Carlsberg ridge and associated structures in the Indian Ocean. How can such movement be accomplished without destroying the structures? Or have such ridges rising thousands of feet above the ocean floor developed since the passage of India? Basalts dredged from the Carlsberg ridge differ chemically from the Deccan basalts of India, being materially poorer in iron and potash, and containing only about half as much radium content. They do not appear to be part of the Deccan flows.

Much additional knowledge of the earth and its tectonic behavior is needed for complete understanding of geologic structures in East Africa.

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CENOZOIC VOLCANIC ACTIVITY IN JAPAN AND SURROUNDING AREAS*

By HISASHI KUNO†‡

The ages and nature of Cenozoic volcanic activity in the Japanese Islands and surrounding areas (FIGURE 1) are fairly well known. Most of the descriptions are published in the Japanese literature, however, and are not easily available to foreign geologists. The scope of this paper is to summarize these data together with the writer's recent observations.

Early Tertiary to Older Miocene. Oligocene volcanic rocks are represented only by pyroxene andesite of the Bonin Islands and alkaline basalt of northeastern Korea. In younger Oligocene or older Miocene, crustal movement took place all over the Japanese Islands. At this time a rift valley was formed traversing central Honsyu, which is called "Fossa Magna." This movement was followed by extensive transgression and volcanic eruption. Lava and pyroclastic rocks were accumulated over the greater parts of northeastern Japan and some parts of southwestern Japan.

In the Fossa Magna region, tholeiitic basalt and pyroxene andesite were erupted first and followed by a little dacite tuff. The total thickness of these volcanic rocks was probably more than 30,000 feet. They were intruded by stocks of quartz gabbro, quartz diorite, and granodiorite. At the contact of some of these stocks, metamorphic rocks ranging from the green schist to the amphibolite facies were formed from the basic volcanic rocks.

In the northern part of Honsyu, the eruption of basic rocks was also followed by the eruption of pumice tuff and lava of dacite and soda rhyolite. But here, the acidic material greatly exceeds the basic in amount, covering nearly two-thirds of north Honsyu and extending into southwestern Hokkaido.

The older Miocene volcanic rocks have been subjected to hydrothermal alteration and mineralization. Most of the Tertiary metallic deposits, including epithermal gold-silver-quartz veins and replacement deposits of copper, zinc, and lead ("Kuromono"), were formed in these volcanic rocks.

Middle Miocene to Pliocene. In the Fossa Magna region, the intrusion of the plutonic rocks was accompanied by folding and faulting, and after a period of erosion a transgression took place in middle to younger Miocene, when nearly half of the present Japanese Islands were covered by the sea. These islands took their present form probably in Pleistocene.

The volcanic activity during the period from middle Miocene to younger Pliocene took place at many scattered centers. Its products, though not so thick and extensive as those of the older Miocene age, are found as many isolated patches in almost all parts of the area considered in this paper.

In the Kurile Islands, Sakhalin, and the Japanese Islands, most of the rocks erupted during this period were tholeiitic basalt, andesite, dacite, and rhyolite.

In central and northern Honsyu, some outstanding centers are known from which tuff breccia with subordinate lava flows were erupted. The rocks are tholeiitic basalt, pyroxene andesite, and hornblende andesite.

In southwest Japan, the association of rock types is slightly different from that in northern Japan. Here, hornblende andesite, biotite dacite, and rhyolite pitchstone are as abundant as pyroxene andesite.

In Sidara basin (halfway between Tokyo and Osaka), the volcanic activity took place during the middle or younger Miocene transgression. The order of eruption is from acidic to basic; first, extrusion of rhyolite pitchstone; second, extrusion of dacite; and third, extrusion and intrusion of pyroxene andesite, tholeiitic basalt, trachyandesite, and alkaline olivine basalt (Kuno).

* This paper, illustrated with lantern slides, was presented at the meeting of the Section of Geology and Mineralogy on March 3, 1952.

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‡ Funds for the writer's work on volcanic fields in central Japan were supplied by the Japanese Government Expenditure for Scientific Research, for which he wishes to express his acknowledgment. He also thanks Professor H. H. Hess of Princeton University for critical reading of the manuscript.

FIGURE 1. Distribution of the Pleistocene and Recent volcanoes.

The activity of the same general age took place at several isolated centers southwest of Sidara basin, namely southeast of Osaka and in the area surrounding the Inland Sea or Setouti region

(between Osaka and Kyusyu).* The rock types occurring in Setouti region are rhyolite pitchstone, garnet-biotite dacite, bronzite andesite, and a little alkaline olivine basalt. The dacite contains crystals of andalusite, corundum, and cordierite, together with fragments of staurolite schist which is entirely unknown in the surrounding area (R. Morimoto). One variety of the bronzite andesite is a dark compact rock, consisting of slender needles of colorless orthopyroxene, a little plagioclase, and brown glass. The mineral composition and texture are so peculiar that the rock is called "sanukite" according to the name of the type locality.

The bronzite andesite contains xenocrysts derived from the underlying granite, and shows an effect of contamination of this material (after K. Sugi).

Deposits of gold, cinnabar, and stibnite are associated with the volcanic rocks of this age (Sidara basin, southeast of Osaka, and Itinokawa in north Sikoku).

A mass of granite-porphyry occurs at the southeastern coast of Kii Peninsula, southeast of Osaka. It is partly extruded on Miocene sediments and partly intrusive into them (after M. Sawatari).

In Miocene, and partly in Pliocene, alkaline olivine basalt and its differentiates were erupted within the region of calcic rock series, although the volume of these alkaline rocks is smaller than that of the calcic rocks of the same age. A differentiated phacolith of alkaline olivine dolerite was found at the western coast of central Sakhalin (studied by S. Iwao and K. Yagi).

At three separated localities near the margin of the southern part of the Fossa Magna region, pillow lava of alkaline olivine basalt of middle Miocene age is found. The lava is intruded by sheets and dikes of alkaline dolerite, teschenite, and trachyte, at two localities northwest and southwest of Huzi volcano and by limburgite and serpentinized peridotite at the other locality south of Tokyo.

In Noto Peninsula (northeast of Osaka) and Oki Island, alkaline olivine basalt was erupted in middle or younger Miocene. This eruption took place at the latest stage of the activity of tholeiitic basalt and andesite which started in middle Miocene in Noto (K. Suzuki, Kuno and others) and older Miocene in Oki. In Oki Island, this cycle of activity was followed by a period of faulting and erosion, and then, in the second cycle of activity which lasted through Pliocene, trachyte, and alkaline rhyolite were erupted (T. Tomita).

There are also several localities of alkaline olivine basalt lava of Miocene age in north Kyusyu and Formosa. More extensive lava fields of this age are found in north Korea and eastern Manchuria.

This region has not undergone intense folding since late Mesozoic. Here we find several separate units of basalt plateaus overlying Miocene sediments. The age of the eruption is probably younger Miocene to Pliocene. All of these plateau basalts were extruded from groups of small vents and not from fissures (Kuno) ("plateau basalt" of G. W. Tyrrell).[1] Most of the lava plateaus may be described as extremely flat shield volcanoes. The inclination of the surface is generally less than 1 degree, but is about 10 degrees locally at the center of eruption.

One of the basalt plateaus, which lies on the Manchuria-Soviet boundary just west of Vladivostok and has a diameter of 50 miles, consists exclusively of typical tholeiitic basalt. The largest plateau, about 120 miles across, on the Manchuria-Korea boundary, is made up mostly of alkaline olivine basalt. The other four plateaus, arranged on the western side of the two just mentioned, are made up exclusively of alkaline olivine basalt (Kuno). A small mass of Tertiary nepheline basalt was found by B. Koto at a point east of Shenyang.

The areal distribution of alkaline olivine basalt and its age relationship toward the calcic rock series in the Japanese Islands are highly suggestive of their genetical connection.

Thus, in Oki Island, Noto Peninsula, Sidara basin, and the southern part of the Fossa Magna region, alkaline olivine basalt was erupted at the close of the volcanic cycle of the calcic rock series, and usually near the margin of the volcanic field. It seems likely, therefore, that the alkaline olivine basalt magma was formed at the latest stage of each cycle in each igneous center. It may have been produced as a late differentiate of an ultimate primary magma, probably calcic olivine basalt magma,[2] which also gave rise to the tholeiitic basalt magma as another differentiate.[3] The alkaline olivine basalt magma may have also originated by remelting of the layer of that composition or fractional remelting of peridotite layer, both of which should underlie the layer of the tholeiitic

* The age of the activity of this region has been recently determined as Miocene or perhaps Pliocene by K. Huzita, T. Kasama, and R. Morimoto.

basalt or quartz gabbro, as postulated by W. Q. Kennedy and E. M. Anderson[4] and by A. F. Buddington.[5] If the melting of the different layers proceeds from the shallower to deeper zones during the igneous cycle, the tholeiitic basalt would have been erupted first and followed by the alkaline olivine basalt.

In eastern Manchuria and north Korea, a zonal arrangement of rock types can be recognized. Thus the tholeiitic basalt plateau is situated in the east, and to the west of this are arranged the groups of alkaline olivine basalt plateaus. Further west, in the central basin of Manchuria, there are lava fields of nepheline basalt and leucite basanite to be mentioned below.

Pleistocene and Recent. FIGURE 1 shows the distribution of chief volcanic cones and some basalt lava fields of Pleistocene and Recent.

In central Manchuria there are four isolated lava fields of leucite basanite surmounted by cinder cones (T. Ogura). Some of them are of historic age.

Two lava fields of olivine-rich alkaline basalt of Recent age fill up valleys in eastern Manchuria and central Korea. Another one (east of Shenyang) consists of more differentiated alkaline basalt or mugearite.

A stratovolcano made up of lava of trachyandesite, trachyte, alkaline rhyolite, and pumice flow deposits, lies on the Tertiary basalt plateau on the Manchuria-Korea boundary (G. Asano). This volcano has a central caldera occupied by a lake.

Uturyo Island is a stratovolcano rising from the bottom of the Japan Sea. It is made up of alkaline basalt, trachyte and leucite vicoite (S. Tsuboi and A. Harumoto).

Several shield volcanoes and small cones of alkaline olivine basalt are scattered along the northern side of southwestern Japan. Small masses of nepheline melilite basalt (A. Harumoto) are also known in this region. Some of these masses may be Pliocene in age.

Thus, in the kratogenic region including the continent and the adjoining part of Japan, the alkaline olivine basalt magma, which formed extensive lava plateaus in Miocene, differentiated to various directions in Pliocene, Pleistocene, and Recent, giving rise to feldspathoidal or highly alkaline basic rocks on the one hand and salic rocks on the other.

In the orogenic region of the Japanese Islands, the alkaline olivine basalt magma also existed in middle to younger Miocene, but was succeeded again by the calcic magma.

In FIGURE 1, volcanoes made up of pyroxene andesite, pyroxene dacite, and basalt (mostly tholeiitic) are distinguished from those made up of rocks with hornblende or biotite phenocrysts. In the latter volcanoes, pyroxene andesite or basalt may also occur.

Calderas are also shown in the figure. Most of them are surrounded by extensive fields of pumice flow deposits and welded tuffs, but some are not associated with these types of pyroclastic rocks. The figure shows that the volcanoes are arranged in several distinct zones.

Although the volcanoes in Kamchatka are shown as being made up of pyroxene andesite and basalt, the mineral compositions of the lava are not known to the writer. According to Tomkeieff[6] the chemical compositions of the rocks are similar to those of the Kurile Islands. The volcanoes of this peninsula are arranged in two parallel zones, the active volcanoes being included in the eastern zone.

Most of the volcanoes of the Kurile zone, which extends to eastern Hokkaido, are stratovolcanoes of pyroxene andesite. At the northern end of the zone is the highest cone, Alaid, which is made up of slightly alkaline olivine basalt and picrite basalt (Kuno).

There are two parallel zones which start from western Hokkaido and join together in central Honsyu. The western zone, which runs near the coast of the Japan Sea, includes stratovolcanoes of pyroxene andesite, hornblende andesite, and slightly alkaline basalt.

The eastern zone comprises various types of volcanoes: stratovolcanoes, lava domes, small shield volcanoes of Iceland type, and calderas. The rocks occurring in the northern part of this zone are mostly pyroxene andesite, and some are tholeiitic basalt and pyroxene dacite. As we go southward, however, hornblende andesite and dacite make their appearance, and become predominant in the volcanoes of central Honsyu.

The volcanoes, mostly stratovolcanoes, within the Fossa Magna region, and those of the Izu Islands constitute a zone which is called the Huzi volcanic zone. From the petrographic character of the rocks, H. Tsuya divided this zone into two subzones.[7] This subdivision has been slightly modified by the writer as follows:

The volcanoes from Hakone (at the northern border of Izu Peninsula) to Iwo-zima constitute

the southern subzone. They are made up of tholeiitic basalt and pyroxene andesite. Iwo-zima is an exception. It consists of trachyandesite (Tsuya).

The northern subzone starts from a rhyolitic volcano Kozu-sima, a small island south of Izu Peninsula (shown by a triangle), and runs to the west of the northern end of the southern subzone, including Amagi and Daruma volcanoes in the central and western Izu Peninsula. In the volcanoes of this subzone, hornblende andesite and dacite, and hornblende or biotite rhyolite, are associated with pyroxene andesite and basalt. The basalt is slightly more alkaline and less siliceous than the basalt of the southern subzone.[7] The hornblende-bearing rocks become more predominant as we go northward; the volcanoes of the northern part of this subzone show association of rock types entirely similar to that of the volcanoes lying adjacent to the east (at the southern ends of the two parallel zones of northern Japan).

In the volcanoes of southwestern Japan, biotite andesite and dacite, which are entirely absent in the volcanoes of Huzi zone and northern Japan, are associated with hornblende andesite.

The western margin of the Fossa Magna region is a great fault scarp about 7,000 feet high (indicated by a line in FIGURE 1), beyond which rise the highest ranges of Japan, about 10,000 feet. The northern range is capped by several cones of pyroxene andesite, hornblende andesite, biotite andesite, and dacite.

Quite similar rock types occur in the volcanoes arranged at irregular intervals along the northern coast of southwestern Honsyu, partly overlapping the area of alkaline olivine basalt. This zone, when extended southwestward, includes volcanoes of central Kyusyu, which also show quite similar association of rock types. Most of the volcanoes of this zone consist of groups of lava domes resting on stratovolcanos or pyroclastic cones.

Aso volcano, lying in the middle of Kyusyu, has a quite different structure and rock association. This volcano consists of a caldera and many stratovolcanoes lying inside the caldera. The caldera, which is about 15 miles in diameter, originated by a collapse of the summit of a flat cone made up of welded tuff of hornblende andesite. The welded tuff has an extensive distribution as shown in FIGURE 1. It is a deposit of pumice flows or nuées ardentes. One of the flows passed over a mountain range as high as about 3,000 feet from its base and filled up the basin lying to the south of the range. During the emplacement of glowing cloud, particles of hot pumice may be carried up by the rising gas, forming a dense emulsion. If the top of the emulsion was higher than the range, the upper part of it could pass over the range. The cones inside the Aso caldera are made up of pyroxene andesite.

Three other calderas with a similar origin and comparable dimension were found by T. Matsumoto in south Kyusyu. Stratovolcanoes of pyroxene andesite also exist either on the margin of the calderas or outside them.

These volcanoes are arranged in a zone which, when extended southward, includes volcanoes lying to the northern side of the main arc of Ryukyu.

A volcano on the northern end of Formosa consists of basalt, pyroxene andesite, hornblende andesite, and biotite andesite (T. Ichimura).

It will be seen from FIGURE 1 that the volcanoes of hornblende- or biotite-bearing rocks are included in two distinct areas; namely, central Hokkaido and the area extending from the southwestern margin of Hokkaido to southwestern Japan. The eastern boundary of the latter area is oblique to the general trend of Honsyu, crossing the eastern volcanic zone of northern Honsyu at a point just north of Tokyo and ending at the boundary between the northern and southern subzones of the Huzi volcanic zone.

This boundary is nearly parallel to the isogals[8] shown in FIGURE 2. The tholeiitic basalt and pyroxene andesite occur in the areas of strong positive gravity anomalies, whereas the hornblende- or biotite-bearing rocks occur in the areas of negative or weakly positive anomalies, in other words, the areas with a thick granitic crust.

In his previous paper,[2] the writer distinguished two different series in the Japanese volcanic rocks. One, which is designated as "pigeonitic rock series," originates through fractional crystallization of basaltic magma. The other, which is called "hypersthenic rock series," is formed when the same magma is contaminated by granitic material. Hornblende and biotite are confined to the latter series.

It is quite likely that the magma erupted through a thicker granitic crust has more opportunities of contamination. Therefore, the rocks of the hypersthenic rock series would be more predominant in the area with a thicker granitic crust. The distribution of the hornblende- or biotite-bearing rocks is in good agreement with this view.

More convincing evidence is obtained by exam-

FIGURE 2. Gravity anomaly (Bouguer anomaly) of the Japanese Islands (after C. Tsuboi).

ining the proportion of the rocks of the hypersthenic rock series to the total number of the rocks collected from individual volcanoes. The examination was made in the Huzi zone which crosses the gravity anomaly contours nearly at right angles.

The percentage of rocks of the hypersthenic rock series is very low in the volcanoes of the southern subzone. It is zero to 10 in the volcanoes of Izu Islands, but gradually increases northward in those of the eastern coast of Izu Peninsula until it becomes about 20 per cent in Hakone volcano.

In the northern subzone, this percentage varies from 100 to about 50. Huzi volcano is an exception, in which the figure is less than 50 per cent.

In the volcanoes north of Huzi, the percentage is higher than that in the volcanoes south of Huzi, varying from about 80 to about 100.

Thus the percentage of the rocks of the contaminated rock series increases with the thickness of the granitic crust.

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*SECTION OF BIOLOGY**

ACTION OF VIRUSES ON RED BLOOD CELLS†

By BERNARD A. BRIODY‡

Although a much larger number of viruses are capable of agglutinating red blood cells (RBC), only the mumps-Newcastle disease (NDV)-influenza group of viruses produces a wide variety of changes in the RBC following the adsorption and subsequent elution of virus. Hirst[1] pointed out that the elution of influenza virus from RBC has all of the essential characteristics of an enzymatic reaction. Gottschalk and Perry[2] have recently concluded that the enzyme associated with influenza virus is an integral part of the viral particle. Viral substrates, presumably closely related to the viral receptors on the RBC surface, which, upon electrophoresis and ultracentrifugation, reveal a single mucoprotein component have been isolated from urine[3] and from the submandibular gland of sheep.[4]

In vitro, human RBC to which the mumps-NDV-influenza group of viruses has been adsorbed and subsequently eluted show the following changes: inability to adsorb fresh virus,[1, 5] "pan-agglutinability"[5], direct agglutination of Rh-positive cells to high titer by anti-Rh blocking antibody,[6, 7] decreased electrophoretic mobility,[8, 9] development of and release of a new "T" antigen which upon injection of rabbits produces "T" agglutinins for viral treated RBC,[10] susceptibility to hemolysis by fresh guinea pig serum,[7] and resistance to hemolysis by saponin.[11] In addition to these alterations, mumps[12] and NDV[13] have a direct hemolytic action on human RBC. Finally, cells treated with mumps virus are agglutinated to high titer by mumps antiserum;[14] cells treated with NDV are agglutinated to high titer by most sera from cases of infectious mononucleosis as well as by anti-NDV serum,[15] and are capable of producing agglutination of untreated RBC.[16]

There is no definite evidence to indicate that these *in vitro* modifications of the RBC surface have any *in vivo* counterparts during the course of human infection with mumps or influenza virus.

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* A paper entitled "The Fractionation of the Serum Proteins by Electrophoresis-Convection," by John G. Kirkwood, Yale University, was presented at the meeting of the Section of Physics and Chemistry on March 4, 1952. No abstract has been received.

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THE RED BLOOD CELL AS A VEHICLE OF VIRUS TRANSPORT*

I. ISOLATION AND IDENTIFICATION OF BLOOD-BORNE VIRUSES

By S. E. MOOLTEN AND ELLEN CLARK† ‡

Viral hemagglutination, studied as an *in vitro* phenomenon, has proved a useful tool in the identification and titration of viruses and as a model of the process of union of virus particles with tissue cells. Shwartzman's studies[1] on lymphocytic choriomeningitis suggest that the transport of virus from point of invasion to site of tissue predilection, as well as the severity of the infection, may be governed by the degree of its association with the circulating red blood cell. Beamer *et al.*,[2] attempting to reproduce the phenomenon of "sludged blood," employed a high-power dissecting microscope applied to the bulbar conjunctiva of young pigs inoculated with hog-cholera virus, and demonstrated agglutination of all or almost all the red cells into small, soft masses. Aside from these observations, little or no evidence has been offered in support of the concept of virus-red cell union in the pathogenesis of disease. The discovery of Newcastle disease virus in the blood of a patient convalescing from severe hemolytic anemia with intense autoagglutination[3] pointed to the need for additional studies on the red blood cells as the vehicle of virus transport, not only in the elucidation of certain types of acquired hemolytic anemia and circulatory abnormalities referable to autoagglutination of blood cells, but also as a practical means of diagnosis of virus infection. A survey program and laboratory screening procedures were therefore developed which had as their object the diagnosis of blood-stream infection with viruses having red cell affinities. In order to economize in time and materials, our survey was directed primarily toward clinical material of the following categories: (1) patients exhibiting autoagglutination of both warm-reacting and cold-reacting types, (2) patients suffering from various types of acquired hemolytic anemia occurring independently or as complication of such conditions as Hodgkin's disease, lymphatic leukemia, systemic lupus erythematosus, and infectious mononucleosis, (3) patients suffering from the latter conditions regardless of the actual presence of anemia at the time of examination, (4) healthy contacts of patients with viremia, and (5) healthy persons, including blood donors, and patients suffering from clinical conditions in which no suspicion of viremia existed. As now set up, the complete survey of an individual case includes the following panel of tests:

1. Titration of serum for degree of autoagglutination at room temperature and at 37° C. (warm agglutination) and at 4° C. (cold agglutination) using the subject's own washed red cells and also normal "O" cells.
2. Coombs test (anti-globulin test) of the subject's washed red cells.
3. Tests of the subject's washed red cells for agglutination in a battery of standard immune sera covering a range of virus diseases.
4. Tests of normal "O" red cells, previously incubated in the subject's serum, against the same standard antiviral sera.
5. Titration of the serum for heat-labile virus-neutralizing factor by comparing unheated serum and serum heated at 56° C. for 30 minutes against a standard virus (NDV).
6. Titration of heterophile antibodies.
7. Inoculation of embryonated eggs with samples of serum, with and without blood cells, employing saline and other virus-free materials as controls.
8. Serologic follow-up for development of specific heat-stable antibodies tested for hemagglutination-inhibition and neutralizing activity against the virus.

Autoagglutination. In our experience, the presence of pronounced warm autoagglutination, not otherwise explained, was found to constitute strong presumptive evidence of the presence of a hemagglutinating virus. Moreover, the diagnostic significance of high titers of cold agglutinins, well known for years in connection with virus pneumonia and other virus infections, seems to have importance also in some of the viremias studied by us.

Agglutination by antiviral sera. The observation that red cells, "sensitized" by contact with a known hemagglutinating virus, are thereby rendered agglutinable in relatively high titer by the corresponding antiviral immune serum was first reported by Burnet,[4] working with mumps virus and NDV. This method of detecting the presence of antibody by the use of red cells sensitized *in vitro* by known viruses yielded important data

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which, unfortunately, lacked sufficient specificity to make the method dependable in diagnosis. Agglutinins for NDV-treated cells, for example, are often present in high titer in the serum of patients with infectious mononucleosis, mumps, infectious hepatitis and certain other diseases;[5] therefore their presence cannot be regarded in itself as evidence of prior infection with NDV.

plicable in the early (viremic) phase of the infection, overcomes certain objections to the older procedure, such as the necessity for awaiting the development of a significant titer of antibodies until late in an infection or until convalescence, and the possibility of nonspecific or group-specific rather than species-specific agglutination of virus-conditioned red cells by such convalescent serum.

TABLE 1

TESTS FOR PRESENCE OF VIRAL ANTIGEN ON RED CELLS AND IN SERUM OF SUSPECTED VIRUS-CARRIERS*

Diagnosis	*Virus*	*Patient*†	*Mumps*	*N.D.V.*	*Influenza A*	*Influenza B*	*Inf. monon.*‡	*L.C.M.*	*J.B.E.*	*S.L.E.*	*W.E.E.*	*E.E.E.*	*Psittacosis*	*Human γ glob.*	*Rabbit A.J.V.*¶	*Normal rabbit*	*Normal guinea pig*	*Normal mouse*
Hemolytic anemia	NDV	S.Bru. a§	—	40	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		S.Bru. b	—	40	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Contact	NDV	N.Kra. a	—	80	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		N.Kra. b	—	80	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Contact	—	E.Bru. a	—	60	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		E.Bru. b	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
?Inf. Mononucleosis	?	G.Han. a	—	40	—	—	160	—	—	—	—	—	—	—	—	—	—	—
		G.Han. b	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
?Inf. Mononucleosis	?	C.Sco. a	—	20	—	—	160	—	—	—	—	—	—	—	—	—	—	—
		C.Sco. b	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
?Inf. Mononucleosis	?	R.Han. a	—	10	—	—	80	—	—	—	—	—	—	—	—	—	—	—
		R.Han. b	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hodgkin's disease	?	A.Jos. a	—	—	—	—	—	—	—	—	—	—	—	—	160	—	—	—
		A.Jos. b	—	—	—	—	—	—	—	—	—	—	—	—	80	—	—	—
Hodgkin's disease	?	C.Koz. a	—	—	—	—	—	—	—	—	—	—	—	—	160	—	—	—
		C.Koz. b	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lupus erythematosus	?	E.Bro. a	—	—	—	—	—	160	—	—	—	—	—	—	—	—	—	—
		E.Bro. b	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lupus erythematosus	—	T.Bro. a	—	—	—	—	—	160	—	—	—	—	—	20	—	—	—	—
		T.Bro. b	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Blood donor	?	L.Fra. a	—	—	—	—	—	160	—	—	—	—	—	—	—	—	—	—
		L.Fra. b	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

* (Results expressed as reciprocal of highest titer of agglutination of virus-conditioned red cells in serial dilutions of known antiviral immune sera.)

† Note: 16 additional patients and controls tested gave negative results with all the above sera.

‡ Infectious mononucleosis serum from patient convalescent from typical infectious mononucleosis (heterophile titer 1:896), normal isohemagglutinins removed by absorption with normal red cells.

§ *a*: patient's own red cells; *b*: normal O cells exposed to patient's serum.

¶ Rabbit A.J.V.: rabbit inoculated with virus obtained from patient A. Jos. (Hodgkin's disease).

The reverse technique, devised by us, appears thus far to have more promise as a diagnostic method. Instead of tests of the serum of the suspected subject for antibodies specific for known virus-treated red cells, the presence of residual virus material upon the subject's own red cell is determined by testing their agglutinability in known specific immune sera. This method, ap-

This new principle was first subjected to trial in the case of patient S.B. and a laboratory worker (N.K.) with NDV-viremia. It was observed that suspensions of their red cells were promptly agglutinated in high dilutions of NDV immune chicken serum, whereas normal cells and cells of patients with active infectious mononucleosis and of a mumps convalescent were agglutinated slightly

or not at all. The practicability of this procedure appears promising in the serologic diagnosis of certain other viral infections as indicated in TABLE 1.

Methods

Virus-conditioned red cell agglutination procedure. To one row of serial two-fold dilutions of an appropriate range of antisera, an equal volume of a 1 per cent suspension of the subject's red cells, washed three times in saline, is added. The same volume of a 1 per cent suspension of normal "O" cells, washed three times in saline after incubation for 1 hour at 37° C in the subject's serum, is added to a second row of the test serum dilutions. The tubes are thoroughly shaken, then left in the refrigerator for two hours and subsequently examined for specific agglutination of typical antigen-antibody type, stable at 37° C.

TABLE 2

DEVELOPMENT OF POSITIVE COOMBS TEST IN VIRUS-SENSITIZED MOUSE RBC EXPOSED TO SPECIFIC (HOMOLOGOUS) IMMUNE HUMAN SERUM*

Treatment of RBC	*Agglutination by antihuman-globulin serum (Coombs test)*
a. Untreated RBC in saline	−
b. Untreated RBC, exposed to human anti-NDV serum, then washed	−
c. RBC exposed to NDV in saline; cells washed after elution of virus	−
d. Same as (c), followed by exposure to human anti-NDV serum, then washed in warm saline to produce stable suspension	+

* Serum of N.K., hemagglutination-inhibition titer 1:640

Virus isolation and identification. Chick embryo inoculation is used in each case, employing 8, 10, and 12-day-old embryos. Following initial isolation of a virus, the age of the embryo at the time of inoculation and the route used vary according to the characters of the strain being studied. As in the case of Newcastle disease virus, a small quantity of the subject's blood (0.1 cc), treated with penicillin and streptomycin, is inoculated into the amniotic cavity of each of 8 embryonated 10-day-old eggs. These are candled twice daily to detect signs of infection as shown by diminished movement or death of the embryo. In 48–72 hours the embryos are inspected and amniotic and allantoic fluids harvested. Cultures are made from these eggs in standard aerobic and anaerobic culture media to rule out bacterial growth.

The fluids are pooled and serial 10-fold dilutions fron 10^{-1} to 10^{-5} are used to inoculate four eggs intra-amniotically and four intra-allantoically at each dilution. Four eggs are inoculated with saline as controls.

Hemagglutination tests with fluid from the infected eggs in serial two-fold dilutions are set up using red cells from a range of species, *i.e.*, chicken, man, guinea pig, mouse, and sheep. Observations are made for hemagglutination titer, the presence of hemolysis, and the type of lesion produced in the chick embryo as part of the characterization of each virus strain. The identity of the virus is explored as far as possible by hemagglutination inhibition tests with known antiviral immune sera, confirmed by neutralization tests in chick embryos, using non-immune sera as control. Fluids from control uninoculated eggs are set up as controls in all hemagglutination tests.

Whenever possible, samples of the subject's blood are obtained repeatedly over an extended period after virus isolation to detect the development of specific antibodies. In the case of patient S.B., for example, heat-inactivated serum had at first no protective effect in eggs against her own virus, nor the California strain of NDV, and failed to inhibit hemagglutination by the virus *in vitro*. During subsequent weeks, a steadily rising titer of heat-stable antibodies against the virus developed, reaching its peak 3 months after the initial studies. Of interest was the presence of a positive Coombs reaction at the time of the antibody peak; this finding suggesting that adsorption of antiviral antibody to virus-sensitized red cells had occurred. The same phenomenon was reproduced *in vitro* with this virus and its corresponding antiserum (TABLE 2).

Summary. Methods are given for detection and identification of viruses in the circulating blood based on their affinities for red blood cells, as manifested by correlative findings, such as autohemagglutination and hemolytic anemia, paralleling in certain respects viral hemagglutination and hemolysis *in vitro*.

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THE RED BLOOD CELL AS A VEHICLE OF VIRUS TRANSPORT*

II. ROLE OF BLOOD-BORNE VIRUSES IN AUTOHEMAGGLUTINATION AND IN HEMOLYTIC ANEMIA

By S. E. MOOLTEN AND ELLEN CLARK† ‡

In the preceding paper an outline is given of our methods of isolation and identification of blood-borne viruses. In this paper a discussion is given of the results of our survey of various types of clinical material and their probable significance (TABLE 1).

A. *Newcastle disease virus.* Of 22 cases of viremia, 5 yielded NDV on chick embryo inoculation. The first was the original case of the series,[1] a 37-year-old woman (S.B.) admitted to the hospital in coma with severe fever and anemia and some jaundice. Intense autoagglutination of red cells (warm and cold) made blood typing difficult. The patient recovered after repeated transfusion (33 pints in 8 weeks). Coombs test was repeatedly negative. During her illness mottled cyanosis was seen in the skin, suggestive of stagnation of blood in minute skin vessels. Also fluctuating mental changes and rapid shallow breathing, interpreted as intermittent stoppage of blood flow in the brain and lung capillaries. The spleen was enlarged. On recovery, antibodies slowly developed and reached a titer of 1:640.

Other cases included that of an 11-months-old infant (A.S.) with two prolonged attacks of jacksonian convulsions and fall in blood count who became completely well after transfusion from an immune donor. Viremia and pronounced autoagglutination disappeared and antibodies against NDV appeared in her blood. In a third case (D.B.) death resulted from intense hemolytic anemia complicating monocytic leukemia. Two other cases were healthy contacts, one of whom, N.K., (a laboratory technician) later developed an antibody titer of 1:640 and provided the blood used in treating the second case.

B. *Herpes simplex virus.* A virus producing lesions typical of herpes simplex on the chorioallantoic membrane of the chick embryo was isolated from the blood of two cases of disseminated herpes simplex of the skin (in one of which the patient had Henoch-Schoenlein purpura), in one case of severe ulcerative colitis, in one case of regional ileitis, and in a newborn infant dying on the second day of life with asphyxia neonatorum and exhibiting numerous herpetic vesicles in the gastric mucosa.

C. *Unidentified viruses.* In 12 other cases lesions characteristic of virus infections were produced in chick embryos, and the amniotic or allantoic fluids produced hemagglutination with or without hemolysis *in vitro* with red cells of various species, and in 2 instances (thus far) produced potent antigens for immunization of rabbits. The cases included acute hemolytic anemia of pregnancy, chronic hemolytic icterus, chronic lymphoid leukemia (3 cases), infectious hepatitis complicated by hemolytic anemia, a healthy blood donor, Hodgkin's disease (3 cases), and systemic lupus erythematosus (2 cases). In two of the cases of Hodgkin's disease the viruses seemed immunologically related, judged by the titer at which an immune rabbit serum agglutinated virus-sensitized red cells of both patients. A virus isolated twice from a patient with systemic lupus erythematosus was found capable of reproducing the "L E cell" phenomenon *in vitro.* A human volunteer (the patient's husband) injected repeatedly with formalin-inactivated virus, developed a rising titer of neutralizing antibody. His serum inhibited the "L E cell" phenomenon when mixed with the pa-

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tient's serum or virus. Transfusions of his plasma into the patient appeared to induce temporary partial clinical remission.

Agglutination test with virus-conditioned red cells. Preliminary studies indicate the practical value of the method described above based on virus-red cell affinity. To a battery of known test sera, prepared in paired serial dilutions, suspensions of red cells are added comprising (1) washed red cells of suspected viremic subjects, and (2) washed normal "O" cells previously exposed to the serum of active infectious mononucleosis, another was a healthy contact (father). The third was the child with hepatitis and hemolytic anemia in whom the possibility of infectious mononucleosis as a cause of both could not altogether be ruled out. Two patients with Hodgkin's disease showed red cell agglutination in the immune rabbit serum produced against the virus isolated previously from one. The cells of the patient with systemic lupus erythematosus as well as those of her husband were agglutinated in significant titer in lymphocytic

TABLE 1

Virus	*Patient*	*Manifestations of Viremia*	*Coombs test*	*Underlying Condition*
N.D.V.	S. Bru.	Acute hemolytic anemia and autoagglutination	−	None
"	D. Byr.	Acute hemolytic anemia and autoagglutination	−	Monocytic leukemia
"	A. Sch.	Convulsive encephalopathy with anemia and autoagglutination	−	None
"	N. Kra.	Autoagglutination (strong)	−	None (contact)
"	E. Sch.	Autoagglutination (moderate)	−	None (contact)
Herpes simplex	J. Hof.	Cold agglutination (strong); vesicles	+	Henoch-Schoenlein purpura
"	H. Die.	Cold agglutination (moderate); vesicles	+	Generalized urticaria
"	S. Buk.	Autoagglutination (strong)	−	Ulcerative colitis
"	E. Mor.	Autoagglutination (moderate)	−	Regional ileitis
"	L. Gue.	Vesicles in gastric mucosa		Congenital herpes
Unidentified	M. Per.	Acute hemolytic anemia and autoagglutination (mild)	+	Pregnancy
"	K. Wil.	Chronic hemolytic anemia and autoagglutination (strong)	−	None
"	C. Sco.	Acute hemolytic anemia and autoagglutination (strong)	−	Infectious hepatitis
"	J. Ste.	Acute hemolytic anemia (mild) and autoagglutination (strong)	−	Lymphoid leukemia
"	W. Far.	Hemolytic anemia and autoagglutination (mild)	+	Lymphoid leukemia
"	M. Hen.	Mild anemia; cold agglutination (mild)	+	Lymphoid leukemia
"	A. Jos.	Mild anemia; cold agglutination (moderate)	+	Hodgkin's disease
"	C. Koz.	Mild anemia; cold agglutination (moderate)	−	Hodgkin's disease
"	M. Ran.	Mild anemia; cold agglutination (mild)	+	Hodgkin's disease
"	J. Har.	Subacute hemolytic anemia; cold agglutination (mild)	−	Systemic lupus erythematosus
"	E. Bro.	Subacute hemolytic anemia; cold agglutination (mild)	−	Systemic lupus erythematosus
"	L. Fra.	Autoagglutination (mild)	−	(Blood donor)

suspected subjects.[7] Noteworthy among the results obtained thus far were the findings suggesting that two of the patients originally showing NDV in their blood, although clinically well, still have virus antigen on their red cells and in their serum as long as a year later. Three other subjects had traces of antigenic material on their red cells which caused their agglutination in relatively high titer in infectious mononucleosis convalescent serum from which the normal isoagglutinins had been absorbed. One was a child believed to have choriomeningitis immune serum, suggesting possible relationships between this virus and the virus isolated from the patient's blood. Further studies along this line are in progress.

Discussion. The observations recorded here, while admittedly preliminary, indicate the need for further systematic studies of the red cell as a carrier of virus material within the organism. The repeated circulation of the same blood cells through virus-infected tissues may be expected to bring about fairly high concentrations of virus material

upon the red cell surface, much in the manner of an "exchange resin." The amounts of adsorbed virus may approach that required to bring about viral hemagglutination *in vitro* and thus probably account for certain instances of autoagglutination and acquired hemolytic anemia. Alteration of red cell protein by certain viruses has been shown capable of inducing antigenic modification which can provoke auto-immune phenomena[2] analogous to the effect of sulfonamide sensitization, accounting for certain types of circulating auto-antibody and the frequent finding of a positive Coombs test. The latter, however, may be induced also by union of viral antibody with virus-conditioned red cells.[3] In our present series of cases of viremia, 7 cases of the total of 22 gave a positive Coombs test at some time in their course. The auto-immune hypothesis of acquired hemolytic anemia and the viral concept are therefore not altogether irreconcilable, the viral mechanism being regarded in such instances as primary to the other.

The surprising incidence of positive results obtained by us may not be altogether fortuitous. Cases selected for virus study were primarily cases of acquired hemolytic anemia of unknown cause occurring independently, or as complications of lymphoid leukemia, Hodgkin's disease, and systemic lupus erythematosus; or cases brought to light by unusually marked autoagglutination encountered during blood typing or similar procedures. The likelihood of technical error appears small, judged by many negative results (40) in healthy control samples and in samples obtained from other conditions than those listed, and by the development of rising antibody titer (heat-stable) in cases from which NDV was isolated, and the specific serologic results obtained in the cases of Hodgkin's disease and systemic lupus erythematosus. The rarity of isolation of virus from the blood in unselected cases on the part of other observers may be due to the normal presence of nonspecific neutralizing factors such as the heat-labile virucidal factor of Ginsberg and Horsfall.[4] The isolation of NDV in the series of 5 cases reported here is noteworthy for the severity of the hematological syndrome produced in three patients by a virus ordinarily held to have relatively low pathogenicity for man in contrast to its pathogenicity for other species.[5] The same reasoning may conceivably apply also in the case of the unidentified viruses. The relation of such viremias to underlying states of debility is not unlikely. The frequent dissemination of other infections (tuberculosis, brucellosis, cryptococcosis, and herpes zoster) in lymphoid leukemia and Hodgkin's disease,[6] and the sopntaneous occurrence of NDV infection in hamsters on a deficient diet[7] point to the basic role of nonspecific factors in resistance. Preliminary tests of serum for nonspecific heat-labile virucidal factor have shown its absence in cases of viremia, contrasted with its presence in measurable titer in cases of recovery from previous viremia (TABLE 2). The fact that circulating virus antigen is detectable by the red cell agglutination test with known immune antiviral sera, despite failure in some instances to isolate virus in chick embryos, adds greater weight to the role of the red cell as an indicator of virus infection—even in latent form—and speaks for the promise of this test as a supplement to current procedures involving actual virus isolation.

Summary. Numerous virus strains have been isolated from the blood of patients exhibiting varying degrees of hemolytic anemia and autohemagglutination occurring independently or as complications of Hodgkin's disease, lymphoid and monocytic leukemia, systemic lupus erythematosus, infectious mononucleosis, and other disorders. These viruses are characterized by red cell affinities including hemagglutination with or without hemolysis *in vitro*. In five instances the viruses were identified as Newcastle disease virus (avian pneumo-encephalitis), ordinarily of low pathogenicity for man. In five, a virus resembling herpes simplex virus was isolated, including cases of disseminated herpes of the skin, ulcerative colitis, regional ileitis, and congenital herpetic gastritis. In the remaining 12 cases the viruses have not yet been identified; in two patients with Hodgkin's disease the viruses appeared identical with each other and serologically distinct; in two patients with systemic lupus erythematosus the viruses also appeared similar, in both cases capable of reproducing the LE cell phenomenon *in vitro*. Re-

TABLE 2

CORRELATION BETWEEN VIREMIA AND PRESENCE OR ABSENCE OF THE HEAT-LABILE FACTOR, HI-NDV*

Patient	*Viremia*	*Unheated serum*	*Heated serum*
C. Koz.	+	–	–
R. Han.	+	–	–
P. Spr.	+	–	–
A. Sch.	–	20	–
E. Sch.	–	20	–
G. Han.	–	40	–

* HI-NDV: Test of hemagglutination inhibition of Newcastle disease virus measured against guinea pig erythrocytes.

sults of a serological procedure involving specific agglutination of red cells of suspected virus-carriers by known specific antiviral immune sera suggest its practicability in the rapid detection of viremia in the early or preclinical phases of infection and in healthy carriers.

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A CRITIQUE ON OUR KNOWLEDGE OF THE ETIOLOGY OF HEMOLYTIC ANEMIA*

By DANIEL STATS AND LOUIS R. WASSERMAN†

Because of limitations of space, we are considering in the discussion which follows only those cases of acquired hemolytic anemia both acute and chronic, with or without hemoglobinemia, for which a reasonable etiological factor cannot be determined and which cannot be grouped conveniently under a definitive heading. Included are the hemolytic anemias secondary to various malignant diseases, and that poorly delineated but common type of case usually called idiopathic hemolytic anemia. At present, we classify these anemias under the heading of "hemolytic anemia due to immune body reaction."[1]

From the point of view of the present discussion, it is of paramount importance to stress the great frequency of a positive Coombs antiglobulin test in these cases.[2] Of all the laboratory tests which can be applied to such cases, the regularity of this finding impresses us as one of outstanding importance. This test is positive especially in the direct method by which the patient's red cells are tested. In a smaller number of cases, in addition to the positive direct test, the indirect test utilizing the patient's serum and normal erythrocytes is likewise positive. These findings are interpreted to mean that antibody protein having great affinity for red cells is adsorbed to the patient's erythrocytes or is free in the plasma. Elution of the antibody from the patient's red cells and recombination with normal cells is readily performed. The important point is that a fraction of the plasma has affinity for normal red cells and can become firmly attached to them simply by incubation and contact of such serum or plasma with the normal cells. It would appear that the basic disorder in the patient with idiopathic acquired hemolytic anemia is his ability to form an antibody which has affinity for red cells.

The recent literature contains several references to the fact that the Coombs test, as usually performed, may detect substances other than antibody gamma globulin adsorbed to red cells. According to the English workers[3, 4] red cells sensitized by different incomplete antibodies such as the cold, anti-A, anti-Rh, or the panantibodies of acquired hemolytic anemia, may be detected by different fractions of the Coombs serum. Moolten and Clark[5] have suggested that albumin, non-specifically adsorbed to erythrocytes, may also be detected by a similar technique. Therefore, a re-examination of the Coombs test is in order.

The great question which arises is the method by which the antibody of acquired hemolytic anemia is formed. It appears highly probable that adsorption of the antibody to the cells causes injury to them and leads to the various consequences of a hemolytic syndrome.

On the one hand, it could be maintained that since the antibody is a panantibody for all human red cells, regardless of blood group or other known antigenic constitution, it could be looked upon as the abnormal product of antibody synthesis by a diseased or deranged reticuloendothelial (or lymphocyte or plasma cell) system. In this view, this type of anemia is a reticuloendothelial disease in which normal red cells are attacked by the anti-

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body. The supporting evidence for this concept consists of the relatively great frequency, as has been known for some time, with which diseases of the reticuloendothelial system such as Hodgkin's disease, chronic lymphatic leukemia, lymphosarcoma, *etc.* are associated with hemolytic syndromes of this type.[6] In such cases the stimulus of the malignant disease presumably causes the production of the antibody.

It is clear that the antibody is a panantibody, since it certainly affects normal cells readily. It could be held that, basically, the patient's own cells are normal but altered due to attack by this agent. There is no evidence to show any preferential attack of this agent on cells damaged or altered by extraneous substances. The susceptibility of normal red cells to the antibody, here visualized as the product of a disordered r.e. system, can be shown also by transfusion experiments.[7] When normal blood is transfused into such a patient there is rapid destruction of the transfused cells following their adsorption of the antibody. If serial determinations of the survival of the transfused cells are made, it can be shown that they are destroyed in a random, or hit-or-miss, fashion. Their rate of disappearance is a function of the total number of such cells in the circulation at any time; a plot of such a series of tests yields an exponential type of curve in which the maximum survival may be reduced from the normal of 120 days to 10 to 40 days or less. Compared to this is the survival of normal cells in a normal individual or in a case of hemolytic anemia due to an intracorpuscular defect. In such a case plotting of the results gives a straight line or linear type of red cell disappearance. In these instances, cell destruction is an orderly process dependent on some characteristic of the cell, such as its age. The fact that, at least in some cases of idiopathic acquired hemolytic anemia, the erythrocyte survival is normal on transfusion of this blood into a normal person, favors the idea that at least physiologically the red cells in this disease are normal.

The other point of view about the origin of a hemolytic anemia places the primary abnormality upon the red cell. It can be conceived that minor alterations in the constitution or structure of the red cell may impart new antigenic properties to it. Such a new antigen could then immunize the patient against the altered red cells. The autoantibody induced would then, of necessity, have relatively low specificity since, as we have already indicated, it affects normal red cells. An extension of this thesis could be made in which diverse and superficially unrelated antigens might provoke antibodies that could attack red cells. There are many examples of heterogenetic response to antigenic stimulation. This subject has recently been reviewed by Wiener[8] who evoked such an explanation to account for the occurrence of some natural agglutinins. He pointed out the overlapping response to many antigens and how even superficially very dissimilar antigens may give rise to similar antibodies. Nothing more obtuse than the demonstrated relationship between such unrelated antigens as type XIV pneumococcus capsular polysaccharide and human blood group A substance need be cited.[9] It seems entirely reasonable to expect that an antibody produced in response to altered or partially-damaged red cells might have marked effects on normal cells.

This line of reasoning finds support and contradiction from various fields. While, as yet, it has not been possible to demonstrate injury of this type to red cells *in vivo*, there are many *in vitro* models to consider. The effect of viruses upon red cells will be mentioned only briefly because this subject has been covered by others. It has recently been reviewed by the two most active workers in this field, Hirst[10] and Burnet.[11] Here we will mention that the changes induced by viruses are subtle. They cannot be described in morphological or structural terms, and, hardly, at present, even chemically. There is evidence that polysaccharide units on the cell surface are involved in the virus effect and in the action of other substances. Immunologically the changes in the cells are marked.

Filtrates of cultures of the cholera vibrio,[13] as well as certain strains of type A *Clostridium Welchii*,[14] affect red cells in a manner similar or identical to viruses. There are 3 main effects. The first, and most important for our subject, is that the cells acquire new antigenic properties.[15] Friedenreich[16] elaborated on the initial observations of Thomsen in this field and fully described the panagglutinable characteristic of cells treated in this fashion. An antibody normally present in all adult and many animal sera, termed the T agglutinin, combines with the new antigen of the treated red cell, the T antigen, to cause hemagglutination. Under these circumstances it can be shown that a potentially active autoagglutinin, awaiting only alteration in red cells to show its

activity, is present in normal sera. No one has ever shown that this reaction is of importance *in vivo*. The T antigen, unmasked by the bacterial filtrate, can be shown also by immunizing heterologous animals with treated cells.[15] An antibody is provoked which shows relatively high specificity for virus or filtrate-treated red cells. This shows the potentialities of cells altered in this fashion and sets the stage for acceptance of the idea that altered cells may be the antigenic stimulus evoking the production of panantibodies in idiopathic acquired hemolytic anemia. Unfortunately this analogy cannot be carried too far since, in the animal experiments, the antibodies to altered cells show high specificity; for the case of idiopathic hemolytic anemia we would expect the reverse. In addition to this, Burnet and Anderson[15] showed that following the treatment of red cells by vibrio filtrate, a soluble substance elutes from the cells which is itself antigenic in a manner quite similar to that of the treated cell. Further experimentation with immunization to altered cells and the survival of such cells after transfusion would be desirable.

In addition to acquiring this new property relating to the T antigen, red cells treated with the enzyme in cholera vibrio filtrates become agglutinable by incomplete Rh[13] and probably other red cell antibodies of various types, including the panantibody of idiopathic acquired hemolytic anemia. It seems likely that this effect, while of great importance in the serological demonstration of such antibodies (especially when the red cells are treated with the enzyme trypsin), does not fundamentally affect the union of the antibody with the red cell but rather is effective in the second stage of hemagglutination, *viz.*, in bringing the individual sensitized cells together into agglutinates. Wiener[17] has proposed a theory to account for this.

The striking fact that treatment of red cells with enzymes alters their agglutinability by viruses emphasizes the similarity or identity of the red cell alterations induced by these diverse agents.[11] Burnet *et al.*[12] have described the receptor gradient of red cells for viruses. This concept concerns the fact that hemagglutinating viruses can be arranged in a series with mumps or Newcastle Disease at the top and swine influenza at the bottom. Treatment of cells with any virus prevents any other virus higher in the series from exhibiting hemagglutination with such cells. The treatment of red cells in stages with the enzyme of cholera vibrio reproduces this gradient in most of its detail. Further stepwise reduction of electrophoretic mobility by virus or enzyme-treated cells paralleling the receptor gradient has been shown.[18]

It would not serve the purposes of this subject to discuss in detail the other agents which have been shown to modify the antigenic structure or makeup of erythrocytes. Agents which act in a manner similar or identical to virus and bacterial filtrates include a variety of enzymes, the most important of which is trypsin,[19] and periodate ions which act as a mild and unique oxidizing agent. Under special circumstances, red cells may adsorb proteins or polysaccharides and thus acquire new properties.[20] In recent years, an entirely new variety of serological tool has been developed whereby red cells adsorb protein of bacterial origin, like tuberculo-protein or mallein, following which hemagglutination by specific anti-tuberculous or anti-glanders serum may be noted. Adsorption of specific polysaccharide may render red cells agglutinable or at times subject to hemolysis *in vitro* in tularemia, influenzal meningitis, or scrub typhus. Moolten and Clark[5] have recently reported about the possibility of modified red cells adsorbing albumin. The effects of physical agents could also be mentioned.

These examples are given to indicate the large variety of *in vitro* techniques for the modification or alteration of antigens of red cells. The possibility exists that cells affected in one of these manners could act as a sufficient antigen to cause autoimmunization. The antibody formed in this manner might have the capacity to attack all red cells and be responsible for a hemolytic anemia. A possible mechanism for the *in vivo* destruction of agglutinated red cells has been shown by Castle, Ham and Shen,[21] and Young *et al.*[22] have recently reemphasized the importance of the spleen in this regard. It is obvious that much work remains before the etiology of idiopathic acquired hemolytic anemia is known.

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SECTION OF PSYCHOLOGY

THE DIAGNOSTIC MEMORY SCALE

I. COMPARISON OF BRAIN-DAMAGED PATIENTS AND NORMAL CONTROLS*

By ROBERT S. MORROW AND JACOB COHEN†‡

Clinical neurologists, with few exceptions, regard memory functioning as an essential part of the neurological examination. Kurt Goldstein,[7] Israel Wechsler[18] and Merritt, Mettler and Putnam,[14] among others, regard memory impairment as a neurological symptom and recommend the study of memory together with other mental functions in the evaluation and treatment of brain injuries. In most instances, however, the measurement of the memory process by the neurologist consists of asking a variety of questions which give a rough evaluation rather than more direct measurement by means of standardized tests.

With regard to the contributions which have been made by psychologists, Klebanoff[12] summarized the situation very adequately by writing, "It is surprising to find the relatively limited number of investigations of a systematic nature of memory ability in cases with cortical damage. The earlier qualitative studies of the psychological alterations in brain disease have frequently indicated that memory disturbances are apparent in such cases, but generally these observations are contradictory and confused. Some investigators report no memory defect whatever, others delimit the impairment to recent memory functioning, and some place emphasis upon a deficit in remote memory. Indeed, the need for further investigation of the presence and nature of such a defect with the use of standardized psychological test techniques is a particularly striking one."

Several attempts have been made, however, to investigate memory functioning in cases of structural brain pathology by utilizing material available in other test batteries, *i.e.*, digit span, or by constructing special materials to measure general or special memory functioning. Zangwill[19] is displeased with the available tests stating that

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these previous memory tests in general use "evolved *ad hoc* without any very adequate definition of their sphere of usefulness." After criticizing three of the four general types into which he classifies existing memory tests, and expressing approval of only one type (the tests of rote learning), he describes his battery of one performance and two verbal tests "to provide criteria of what is commonly called organic memory retention defect." Graham and Kendall[8] constructed a visual test of memory consisting of 15 designs which gave significant mean differences in scores between a group of brain-damaged patients and a control group. Benton[3] also developed a memory for designs test "to supplement the auditory-vocal digit span test as a measure of retention."

Studies in which memory function was investigated by itself or as part of a series of tests of intellectual functioning relating to structural brain pathology, were done by Conkey;[6] Hunt;[11] Aita, Armitage, Reiten and Rabinovitz;[1] and Armitage.[2] In the research on lobotomy the investigators who studied the effects on memory were Lidz,[13] and Halstead,[9] Rylander[15] and Stauffer[16] in the Columbia-Greystone project. Zubin and Barrera[20] studied the effect of electroshock, and Hoch,[10] in discussing "artificial brain damage" resulting from electric shock, postulates emotional factors as contributing to the organic interference with memory.

Recognizing the need of psychologists for a standardized memory test, David Wechsler[17] developed a memory scale consisting of seven subtests. Of great interest and frequently of considerable clinical value is the memory quotient which can be obtained from this test. Cohen,[4] however, used the Wechsler Memory Scale on equated groups of organic schizophrenic and neurotic patients and found that it failed to differentiate among these three groups.

Statement of the Problem. It can be seen from the related literature that there is no unanimity of results, with differences found in some studies and none in others and that there exists, also, a need for a standardized, quantifiable approach to the study of memory. The main problem was to try to develop a group of simple tests which would include valid findings from the neurologists' experiences as well as information from other research regarding recognition, recall, and retention. Since this was to be a test primarily for brain-damaged patients an attempt was made to include only concrete and meaningful content rather than abstract designs, nonsense materials, *etc.* Actually this memory scale was developed, first, to yield objective psychometric data in the study of memory functioning in structural brain pathology, and second, for the purposes of differential diagnosis; both problems being interrelated. The present report gives a description of the scale as well as preliminary research on the comparison between patients with structural brain pathology and equated normal controls.

Description of the Test Materials and Procedures. There are four tests in the present pilot form of the scale. Test I is a test of recall of old learning involving objective facts which can readily be scored. Included here are sixteen questions on orientation for time and place as well as questions presumed to have been universally learned such as dates of the Declaration of Independence and Pearl Harbor, years in which World War I and World War II ended, dates of national holidays, *etc.*

Test II is a test of unmotivated immediate recall of new learning as well as retention following retroactive inhibition. A card containing the pictures of 26 common objects is handed to the patient with the following statement: "I want you to name all the objects on this card." Nothing else is told the patient. He may name these objects in any order and his naming of all the objects is accepted and noted if it differs from the name given on the record blank (incidental to the main purpose of this test is the fact that it helps to detect the anomic form of aphasia). The examiner then removes the card and requests that the patient name all the items that he can remember. After Test III has been administered, as interpolated material which takes about 10 minutes, the second recall of Test II is given. The formula used is as follows: "Do you remember the card with the pictures of common objects I showed you before? Tell me as many of them as you can still remember." Retention percentage as a measure of retroactive inhibition is measured in terms of the ratio of the later recalls to the number immediately recalled.

In Test III fifty-four pictures of outstanding Americans and world-figures, past and contemporary, drawn from the fields of politics, science, and the military and entertainment worlds are presented for identification. A full score is given for the correct name, with partial score allowed for identifying information which indicates that the

TABLE 1

DIAGNOSTIC DISTRIBUTION OF THE BRAIN-DAMAGED

Diagnosis	*f*	%
Neoplasm	21	48
Penetrating Injuries & Traumas	11	25
Epilepsy	10	23
Generalized Encephalopathies	2	5
N =	44	101%

TABLE 2

CLASSIFICATION OF NORMAL CONTROL GROUP

Category	*f*	%
Hospital Attendants	23	50
Clerical & Supervisory Employees	19	41
Minor Surgery Cases	4	9
N =	46	100%

The brain-damaged group consisted of 44 patients diagnosed as suffering from structural pathology of the cerebrum by staff neurologists. None of these patients was chronic or deteriorated but represented the patients encountered on an active neurological ward. The actual diagnostic groupings are given in TABLE 1.

The normal control group consisted of 46 subjects who had no history of a neurological or psychiatric diagnosis. They were predominantly hospital employees as shown in TABLE 2.

To assure the control of pertinent variables, the two groups were equated with regard to three variables: (1) age, (2) years of school attendance (Ed), and (3) the sum of the weighted scores for the general information subtests of the Wechsler-Bellevue Intelligence Scale, Forms I and II. Evidence has been adduced in previous research[5] that the information subtest provides a good measure of present general intellectual functioning; the two subtests were combined for the purpose of increasing reliability and, concomitantly, validity. The central tendency (mean), variability (standard deviation), and t-test for significance of mean difference between the two groups for each equating variable are given in TABLE 3.

TABLE 3

MEANS, STANDARD DEVIATIONS AND t-RATIOS FOR THE EQUATING VARIABLES

	Normal Control N = 46		*Brain-Damaged N = 44*			
	M	*S.D.*	*M*	*S.D.*	*t*	*P*
Age	30.31	6.04	31.96	6.76	1.19	not significant
Ed.	10.96	2.60	10.41	3.03	.91	not significant
Information	21.41	5.15	20.16	4.88	1.26	not significant

TABLE 4

MEANS, STANDARD DEVIATIONS AND SIGNIFICANCE OF DIFFERENCE BETWEEN MEANS OF NORMAL CONTROL AND BRAIN-DAMAGED GROUPS ON DIAGNOSTIC MEMORY SCALE VARIABLES

	Normal Control N = 46		*Brain Damaged N = 44*			*P (Level of Significance)*
	M	*SD*	*M*	*SD*	*t*	
I. Recall—Old Learning	11.37	2.69	10.04	3.00	2.19	.02
II. Recall—New Learning						
First Recall	12.24	3.00	10.66	4.65	1.90	.03
Second Recall	10.61	2.88	9.36	3.24	1.66	.05
Retention Per cent	88.46	22.10	78.40	29.09	1.83	.04
III. Recognition—Old Learning	35.19	12.79	32.29	11.48	1.12	Not significant
IV. Combined Recognition & Recall New Learning	10.89	5.83	8.34	5.52	2.10	.02

subject clearly recognizes the person but does not recall the name.

Test IV is a more complicated test of combined recognition and recall (new learning). This entails a presentation by the examiner of a series of five photographs of persons together with identifying name and, as scoreable "memories," six or seven simple facts about each. The patient is asked to recognize these five from among fifteen other pictures and to recall the names of these people as well as all the factual items he can remember about each.

Subjects. The ninety subjects of the present investigation were all male veterans below the age of 45 who were tested during the past two years at the Bronx VA Hospital.

Hypothesis and Results. The generalized hypothesis for all the variables studied was that the brain-damaged group would manifest significantly lower mean scores than the normal con-

trol group. This hypothesis was substantiated for six out of the seven variables (three out of the four tests) studied. The detailed results are given in TABLES 4 and 5. TABLE 4 presents the means, standard deviations, t-ratios and P values of the significance of the difference between means for the six quantitative variables.

TABLE 5 is a contingency table which compares the groups with regard to success in recognizing the five faces from among the group of twenty in Test IV—Combined Recognition and Recall. This leads to a chi-square value significant at the .02 level.

TABLE 5

SUCCESS IN RECOGNITION OF FACES IN TEST IV.

	All Five Recalled	*One Failed*	*Two or More Failed*	*Total*
Normal Control	38 (83%)	6 (13%)	2 (4%)	46 (100%)
Brain-Damaged	27 (61%)	7 (16%)	10 (23%)	44 (100%)

Chi-Square = 7.22, 2 degrees of freedom, P = .02.

Discussion

1. Recall (Facts). The brain-damaged patients on the average were less able to recall the facts than were the normal controls, with a difference significant at the .02 level. This is particularly noteworthy because of the fact that the groups did not differ significantly on the combined information test, whose items seem superficially similar to those on this test. The similarity, however, is more apparent than real. As will be recalled, most of the items on Test I were selected so as to require that the subjects recall a fact to which he was certain to have been exposed in the course of his life (*e.g.*, "Who discovered America?," "Who was the first President of the U. S.?," "When is Election Day?," "When was Pearl Harbor?," *etc.*). These are all matters of common knowledge. The combined information test, on the other hand, uses items whose purpose it is to discover the subject's specialized knowledge, actually in part to measure the degree of the subject's exposure to items of information of increasing difficulty because of their increasingly esoteric character. From this logical analysis, we can therefore tentatively conclude that brain-damaged patients have difficulty in recalling facts of an incidental general nature to which they have been exposed and which they presumably knew at one time.

2. Recall: New Learning. This test involves the remembering of photographed drawings of objects, when the subject has not been told that he is to memorize the objects, but merely to name them. When asked to recall the objects immediately following his naming of them, the brain-damaged subjects named significantly fewer than did the normal controls (.03 level of confidence). Following some interpolated material (the next test, which takes about ten minutes), when requested again to name as many of the objects as they could, the brain-damaged subjects named fewer than the controls, a difference significant at the .05 level of confidence. An attempt was made to measure the degree of loss through retroactive inhibition by a score which is the percentage of the number originally recalled which was recalled on the second trial. This score, referred to as Retention Per Cent in TABLE 4, also discriminated significantly between the groups (at the .04 level), the brain-damaged subjects showing a lower average score than the normal controls. The actual mean scores are given for both groups on these three variables in TABLE 4.

From these results it can be concluded that in incidental learning and recall of visually presented objects, normals perform more adequately than brain-damaged patients both immediately following the presentation of the stimuli and after about ten minutes of interpolated material. Further, normals also retain a higher percentage of what they had originally learned when retested after this short lapse of time.

3. Recognition: Old Learning. The test we used to evaluate the recognition of old-learned material required the identification of 54 famous people from their photographs. Although the difference between the groups lay in the hypothesized direction (TABLE 4), it was not sufficiently large to be reliable. The experimental hypothesis can not be substantiated. It would be unwarranted to conclude that there is no difference between brain-damaged and normal individuals in their recognition of old-learned material. The test used samples too many other factors, such as movie attendance, newspaper-reading habits, and contemporaneousness of the famous figures, the var-

iance of which may be swamping the factor whose measurement was intended. Only further research can elucidate the relationship, if any, between cerebral damage and recognition of old-learned material.

4. Combined Recognition and Recall: New Learning. On this test, following a presentation of five photographs of men and some facts about each, the subjects were required to select the five photographs from among a larger group and to recall as much as they could about each. The brain-damaged patients recalled significantly fewer facts than did the normal controls, the difference being significant at the .02 level (TABLE 4). In addition, a comparison was made between the groups on the number of photographs (out of five) correctly identified (TABLE 5). The brain-damaged patients had a much higher incidence of failure to recall two or more of these than did the normal group (23 per cent to 4 per cent). Obviously these two variables, number of facts remembered and number of faces identified, are correlated, but then so are the functions of recall and recognition which they respectively measure. It is therefore concluded that in a test involving both visual recognition and verbal recall of newly learned material, brain-damaged patients function at significantly lower level on the average than do normals.

The Significance of the Results. This study has served to demonstrate certain points:

1. It is possible to develop psychometric instruments in the area of memory functioning which distinguish statistically between the average performance of brain-damaged patients and that of normal controls.

2. Not all memory tests, no matter how adequate on technical psychometric criteria, are capable of making this distinction. In the present study, it was seen that one of the tests (Test III), which on *a priori* grounds could be considered as good a test as any of those employed, failed to significantly distinguish between the means of the two groups. This points to the need for careful experimental validation of test items in this area before they are used as aids in clinical diagnosis.

Limitations of the Study. The purpose of the present study was primarily theoretical and exploratory. Although it is considered possible to ultimately develop psychometric techniques which will aid in and objectify the clinical examination of neurologically suspect patients, the experimental battery of tests herein reported is not held forth as such a technique for two reasons:

First, the establishment of the fact that two groups give statistically significant differences in average scores on a test does not mean that the test can be used with success in individual diagnosis unless the differences are so great as to reduce the overlapping between the two groups to some insignificant percentage of their number. A glance at TABLE 4 reveals that the actual differences between groups on the significant variables are small relative to the variabilities of the groups. Only through further refinements of the scale, mainly by statistical item-analysis (which is now in progress), is it hoped that it will be possible to reduce the overlapping to a point where the scale is of use in individual diagnosis.

Secondly, it must be stressed that the success in this study lay in contrasting the brain-damaged group with a group of neuropsychiatrically normal individuals. This is of theoretical importance but of much less practical importance, since the typical differential diagnostic problem is not between a clinical entity and normality, but among clinical entities. At the present time, it is not yet known whether the scale can distinguish brain-damaged patients from functionally psychotic or neurotic patients with memory complaints.

Summary and Conclusions

The present study is the first report of a larger investigation which concerns itself generally with the pathology of memory. More particularly it represents a psychometric approach to memory functioning of brain-damaged patients, utilizing the type of material encountered in clinical examinations, but in a systematic, standardized fashion. The present report described the four experimental tests which constitute our provisional battery and the results of a comparison of 44 brain-damaged patients with 46 normal controls. The two groups were equated with regard to age, years of school attendance, and level of general information. All subjects were male veterans below the age of 45.

The four tests yielded seven variables. Upon statistical analysis by means of t-tests and chi-square, six of these were found to lead to differences significant at the five per cent level or better between the brain-damaged patients and controls. These variables measured (1) recall for old learned verbal material; (2) immediate incidental recall for new learned material; (3) delayed re-

call for new learned material; (4) retroactive inhibition; (5) recognition for new learned material; and (6) recall of complex new learned material. The variable which did not prove significant was one with which it was intended to measure recall for old learned visual material.

The general conclusion is that a psychometric approach with familiar meaningful material in the study of the memory functioning of brain-damaged patients seems fruitful.

In future investigations it is planned to attempt the following: a comparison of brain-damaged patients with psychiatric patients and the latter with normals; a comparison among various types of brain-damaged patients, *i.e.*, acute vs. chronic, mild vs. severe, focal vs. generalized damage, *etc.*; an item analysis of the results of the above studies as well as the present one for the purpose of sharpening the instrument to the point where it may be useful as a diagnostic aid.

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SECTION OF MATHEMATICS AND ENGINEERING

SCIENTIFIC DEVELOPMENTS IN INDUSTRIAL ENGINEERING*

By DAVID BENDEL HERTZ†

In a broad sense, all engineers employed in industry are industrial engineers. Yet the term "industrial engineer" is reserved for the individual who deals primarily with the economic aspects of industrial operations, expressed in particular with respect to the measurement of the performance characteristics of labor in those operations. The industrial engineer has been especially concerned with these measurements as they have been applied to incentive plans.

No attempt will be made to survey the history of "industrial," "management," or "administrative engineering"—growing as it did from the not too primitive beginnings of Babbage (in 1832);[1] out of the work of Taylor, Fayol, Gantt, and others; and developing through the period of the efficiency expert to its recognized, but not too high, estate of the present day. Rather, four modern models of industrial operations will be

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outlined. The concepts involved in solving the management problems described by these models will be demonstrated to require engineering knowledge of the highest order. The attempts to solve these problems will be presented as scientific developments in industrial engineering. Without specifically discussing the utility of industrial engineering in areas such as methods study, safety, materials handling, plant layout, personnel, *etc.*, the entire field will be included within a broad framework of modern scientific methodology.

The Columbia Encyclopaedia defines engineering as "the science dealing with the design, construction and operation of the various structures, machines, engines, and other devices used in industry and in everyday life." Further, it has this to say about industrial engineering: "[it] is less clearly defined than most engineering fields, [and] the industrial engineer deals with such problems as the improvement of production methods, efficient arrangement and working of machinery in a plant and the planning of production."

Actually, there should be no real problem in defining the role of the industrial engineer in the future if his objectives and methodology are kept on an engineering level. As the science dealing with the design, construction and operation of industrial mechanism, his field is properly methods, layout and control—but with engineering or scientific methods replacing those which commonly exist today. The essential elements of the definition are design, construction and operation of some part of an industrial enterprise. The engineer generally wishes to optimize some aspect of performance within some group of overall restrictions.

The industrial engineer is concerned with the productive combination of men and machines under certain economic restrictions, including quality of output. In the large sense, this may be considered a problem of organization. The industrial engineer has viewed organization as coming within his cognizance (although it is not easy to see why this should have been logically so, since it is only recently that the necessary tools to study organization scientifically have been available). Therefore, we find the literature, replete with books on organization, typically giving advice such as the following trivial example: "Authority should be commensurate with responsibility." Such normative comments give no means of measurement of either subject or predicate. Even more careful statements on the subject by engineering thinkers have been little more operational.

Organization in a man-machine structure is a complex combination of sets of various kinds of interacting situations. It is only recently that servo-mechanism and information theory coupled with modern concepts of probability have given us the clue as to how this problem may be systematically attacked.[2] No attempt will be made here to present these tools in an operational fashion, but it may be pointed out that they are engineering subjects, taught in engineering schools. It is likely they will form the core of future industrial engineering study. In addition, the industrial engineer will be vitally interested in the research of the psychologists, sociologists, and anthropologists so that he may understand the human element of industrial organization.[3] The industrial engineer must look to the life scientists for his basic information just as he turns to the nuclear physicist for basic theory and data in the field of nuclear engineering.

An association comprises a system of elements *i.e.*, men, machines, tools, materials, paper, *etc.*, such that a change in the state of some elements is followed by a determinate pattern of changes in other elements.[4] From one point of view, the changes in state can be called messages. Messages can originate internally or externally and may be transmitted within the association from element to element by means of a channel. A channel may be defined as the internal system permitting patterns of change to be transmitted so that the properties of a message are more or less isolated from other changes in the system. The "content" of these messages may be defined as "information," which in turn may contain defined quantities such as "intelligence" or "noise" or both. The same physical message may convey different information when transmitted to various elements over various channels. Noise itself may have a number of components: error, irrelevancy, and a component for maintenance of the channel. It should be remembered that any measures of such defined quantities as "error," "irrelevancy," "intelligence," *etc.* are relative to some knowledge of desired input-output relationships. On the other hand, the physical change in state within the system may be the same for different values of these quantities.

Now, from this viewpoint, the structure of an association is equivalent to the statistical description of what messages are communicated through what channels, and what changes in state result

from the intelligence, *etc.*, conveyed by these messages.

If we wish, we may term the system, this association of men, plus inert and dynamic elements, a network. The function of the network is to transmit messages, both internally conceived and received externally by the elements in contact with other systems. Messages lead to other changes in state, one class of which may be production, another purchasing, *etc.*

Now, in most systems such as these, there is some capability of modification of the change-of-state patterns resulting from given messages, as a result of what has happened with respect to production, or purchasing, *etc.*, whereby the future pattern is in some way proportional to the deviation of the results from the information relating these to some specific set of goals or objectives. This modification process is directly analogous to the so-called "feedback" of servo-mechanism theory.

This same feedback is used also to modify the rules whereby the messages are combined, transmitted, and to regroup combinations of elements (which is called re-organization) and to recompare results with different goals. Further, the net has a combination of memories, whereby it can learn and store up sets of experienced messages for future use.

There is no mere analogy to servo-mechanisms or computers, but rather the concept of a model of organization structure. Studies of organization based upon such a model would involve information and servo-mechanism theory, *etc.* It is a matter of some importance to the industrial engineer that the concepts are all expressible in the language of science—mathematics—rather than loose and vague prescriptive statements.

Purchasing is one specific area for studying the operation of such a network at the present time. The number, kind, and results of messages in this case are quite determinate. He who orders (through a requisition to the purchasing department) 5 gallons of hydraulic fluid does not expect to receive 5 Burmese elephants. Indeed, the likelihood that he will do so is quite low. On the other hand, the probability that he will receive 1 gallon or 10 gallons, or some oil other than that specified, is not quite as low—and, as a matter of fact, may be directly measurable. From this standpoint alone, information and servo-mechanism theories play a most important role in the scientific development of industrial engineering.

A different aspect of industrial engineering must also be considered: production, production methods, and production control. Here two models are useful, both somewhat different from the one described above. It will be desirable, in some sense, to amalgamate these two models into a more general model of the controlled-production process. Both models are to be based upon engineering and mathematical concepts, and in the long run, should not leave the industrial engineer-manager with the statement, "It works, but I don't know why."

The production process may be described as sets of "operations" performed upon similar "elements." Here, element has the same connotation as it did in the organizational model above. The operation-element combination is a sub-process. The sub-processes are defined as "stochastic," in the statistical sense that they may be represented by probability functions with time parameters.

In this model each sub-process has an input and output which may be described in terms of production time, quality, set-up time, *etc.*: functions which are not necessarily independent. For the manufacture of a given product out of a range of possible products there are combinations of the process network which are feasible (that is, there are restrictions on any given product which make it necessary to manufacture in some class of ordered process sequences). The entire process may be visualized as irreversible (in the thermodynamic sense), but the changes in state of the product are roughly analogous to a decrease in entropy.

For the input-output function of any sub-process, with respect to time, for example, there is a probable rate of input of an element to be worked on, and a probable rate of output of an element which has been worked on. Bradley has termed the resulting function an emergence function which is the probability that an element which has entered a sub-process at time "zero" will leave it at time "X."[5] It turns out that this emergence function may be determined empirically for a given production case.

For a production system the network of sub-processes, with their attached emergence functions, seems to present a model which lies between the fields of probability theory and linear network analysis. Production changes due to variations in emergence functions may be obtained from the application of the methods of electrical circuit analysis, where Laplace transforms, Fourier integrals, or operational calculus may be utilized to solve the equation sets. Such a model as this

will provide more precise descriptions of the operation of a production process and the results of changes in specific elements.

Another production problem is that of control, and here the model is somewhat different. The idea of control involves action for the purpose of achieving a desired end. The model will require original data as evidence, prediction, and a degree of belief in the prediction based on the evidence, all interconnected.

The model, according to Shewhart,[6] comprises the following:

"1. Specify in a general way how an observed sequence of N data is to be examined for clues as to the existence of assignable causes of variability.

"2. Specify how the original data are to be taken.

"3. Specify the criterion of control that is to be used, indicating what statistics are to be computed and how they are to be used in computing action or control limits for each statistic.

"4. Specify the action that is to be taken when an observed statistic falls outside its control limits.

"5. Specify the quantity of data that must be available and found to satisfy the criterion of control before the engineer is to act as though he had attained a state of statistical control."

The control model requires an understanding of the physical elements of the production process, the ability to measure (or obtain the data), and the ability to derive mathematically the statistics required to justify statements concerning control or lack of control. In other words, scientific developments in industrial engineering require a sound background in physical science as it relates to industry, and in the probability and statistical inference branches of mathematics. Techniques such as time study will be recognized in the future for what they are—tools of measurement—and used in the same way as such tools are used in other branches of engineering: to measure. The industrial engineer of the future will not be "a time study" or "methods man"—no more than the mechanical engineer is a "pressure gauge reader" or "instrument fitter."

Control of a production process has little meaning unless it is a part of the design of that process. Therefore, the foregoing two models may be tied together through the medium of the probable rates of input and output which determine the emergence function for each sub-process. If the system is to be "controlled" the state of control of each of these input-output functions must be subject to the operations of the control model. One must be able to specify, measure, and take action at each point in the production network.

The industrial engineer, utilizing some such production models as these, can design and control the production process in a scientific manner. He is able to approach plant layout, for example, from an entirely different view than he has in the past: he will minimize some function, such as internal transport distance, or the probability of down time, *etc.*, with respect to a set of real variables in terms of engineering objectives. The Shewhart model has been used in this way to establish "quality control" as opposed to the older concept of "inspection." Further, there are now a few instances in industry where the application of the combined model is already being achieved. A number of practitioners in operations research are doing this in relation to inventory and production control problems. Incidentally, a portent for the industrial engineer as to scientific developments in his field undoubtedly lies in the fact that the operations researchers are notably physical scientists and mathematicians. It may be that the term "industrial engineer" eventually will be reserved only for those in time study, *etc.*, and the engineer described here will be called an "operations engineer" or some other such name.

There is another set of conditions the engineer must impose on the industrial process—economic conditions—leading to a scientific model of economic behavior. In a sense, such a model only requires that cost functions or schedules be attached to the various system elements or changes of state of those elements. Therefore, any of the previous models can be developed in terms of the economic picture (for example, economic objectives are implied in the control model, *etc.*). Dantzig's Linear Programming, Koopman's Linear Activity Analysis,[7] and Leontief's Inter-industry Analysis,[8] among others, are present attempts to attack this phase of the problem. Scientific developments in industrial engineering, certainly, require familiarity with the application of this kind of thinking to industrial problems.

It is to be anticipated that there will be anguished howls from many who will say this is "too complicated," "too mathematical," "too theoretical," "impractical," *etc.* Perhaps the only answers to these are that the impractical man is the one who is willing to lean on his guesses and who does not care to determine the basic cause system underlying his operations, and that quality control

and other major advances were subjected to exactly the same kind of criticism.

It should also be clear that the kinds of analytic methods required for handling these types of models may be best performed with computers. Computer theory and practice is forging ahead rapidly. There is no doubt that the industrial engineer has a computer in his future. Application of the unique talents of computers, to produce solutions to the sets of equations such models as these will develop, is under study to give production schedules, inventory policies, organizational designs, *etc.* Such devices cannot be applied by hunch or guesswork, but only by creative scientific understanding of the problems and the devices themselves.

In summary, four major models have been considered briefly: (1) organization and communications, (2) production, (3) control, and (4) economic. They are far from perfect at present, but they point the way to the future and clearly delineate the important scientific developments in industrial engineering.

The industrial engineer in the past has been led away from the engineering aspects of his profession toward those of the "pseudo-explanation," *i.e.*, an explanation which sounds very good but has no scientific or operational verifiability.[9] As engineers, the future means a return to the past in the sense of reshaping the scientific links and developing a methodology as sound as those already developed in other branches of engineering. It will not be possible, as it is today, for just anybody to turn his talents toward the engineering of organization, production, and control. Those who undertake to solve the difficult problems in this field will have to be scientists, in the true sense of that word.

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SECTION OF ANTHROPOLOGY

CONTEXT OF REBELLION AND ACCOMMODATION IN POST-WAR SICILY*

By VINCENZO PETRULLO†‡

Sicily, looked upon as politically inert, has become an area of major concern to observers of political developments in Italy. A recent article published in one of our leading national weeklies entitled "Is Sicily Ready to Explode in Our Faces?" is an example of the growing awareness that the traditional views concerning Sicily may have to be considerably modified.

It has been generally held that the Sicilians might be capable of individual acts of rebellion but not of concerted rebellious political action. The overt political behavior of the Sicilian people would tend to bear this out. They accepted Fascism easily and gave it up equally easily. In the post-war plebiscite on the question of the monarchy most Sicilians voted to retain it. In the national elections of 1948 they voted for the parties of the right and center. In fact, the American government in 1948 was so convinced that there was nothing to fear in Sicily that it almost closed its only office of information on the island.

What has gone unobserved is that the Sicilian people are in a state of chronic rebellion against almost every facet of their existence. Varying with their social and economic status, they are in rebellion against a hopeless economic situation, traditional social duties and obligations, against

* This paper was presented at the meeting of the Section of Anthropology on March 24, 1952.
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‡ The author is indebted to the Wenner-Gren Foundation for making possible an extensive field study in Sicily in the post-war years. This article is based primarily on the study.

constituted authority, even against life itself. Though most keenly manifested, of course, by those who despair of being able to furnish even food for their families, it is found even among the well to do. However, the very culture against which the Sicilians seem to be in rebellion has supplied them with a technique for dealing with it—accommodation. As long as the area of accommodation is not reduced drastically rebellion may find little overt expression, such is the strength of the traditional social-economic-religious complex which governs the public behavior of the Sicilian. If, however, the possibility of accommodation is further restricted, or the traditional compulsion to live up to one's duties and obligations is weakened, the "explosion" may come.

To begin with, most Sicilians are born in an economic situation which nearly defies solution. Sicily is as large as Vermont, but it is more arid and more mountainous. It has a population of over 4,500,000, *i.e.*, about twelve times that of the Green Mountain State. With a population of 450 per square mile, it is one of the most densely populated agricultural areas in the world.

Sicily is poor in industrial resources. With the exception of sulphur, of which there are large deposits, it is almost totally lacking in mineral wealth. Its forests have been cut down. Its water power potential is not high. Industrially it cannot compete with North Italy, and as a result its economic position is becoming worse rather than better; better communications favor the importation of factory-made commodities which formerly were produced locally. The handicraft industry is dying out.

Sicilian agriculture suffers from rugged terrain, seasonal droughts, soil erosion, primitive methods of agriculture, absentee ownership of the land, and competition from regions more adapted to modern mechanized agriculture. Famous as the granary of Rome, reputed to have been the richest land of Europe during the Saracenic and Norman periods of its history, Sicily today cannot produce enough to give most of its people a standard of living much above a mere subsistence, though 94.6 per cent of its land surface is under cultivation.

About one half of the population derives its living directly from tilling the land but, while it is estimated that a minimum of 12 acres of land is needed to furnish a family with a minimum standard of living, about one half of those who till the soil own no land.

As of January 1, 1948, there were 1,241,731 proprietors in Sicily with total holdings of 6,149,265 acres. Of this number 726,412 did not own more than one and one fifth acres each. The holdings of this group totalled less than 300,000 acres. Comprising 58.5 per cent of the proprietors, this group owned less than 5 per cent of the total arable land. In fact, 98.3 per cent of the total number of proprietors owned only 40 per cent of the arable land, or an average of about two acres apiece. On the other hand, 1,289 proprietors owned 1,548,622 acres or 25.1 per cent of the total arable land. One hundred and fifteen proprietors owned more land than 725,000 proprietors. When it is also considered that much of the best land is in the hands of the large landowners, the plight of the small proprietor becomes evident.

In the post-war years, the Sicilian farm hand has earned as little as forty cents a day—working no more than 180 days a year if fortunate enough to find "full" employment. At the same time the cost of everything that he might need, including food, sky-rocketed. In 1948, cheap shoes cost $12, a suit of clothes, $30; a package of the cheapest cigarettes, 20 cents; a pound of bread, 18 cents; a pound of meat, 60 cents. To understand the plight of the Sicilians, we can imagine an American workman earning $50 a week having to pay $250 for a pair of shoes, $600 for a suit of clothes, $4 for a pack of cigarettes, $9 for a pound of meat—and everything else in proportion.

Housing for most of the population is generally poor. The usual home for the peasantry is a house of two small rooms, one above the other. The lower is used as a stable and the upper as the living quarters for the entire family. These crowded conditions no doubt play a role in the development of the personality of the poorer people. In central Sicily, in towns like Caltanisetta, Enna, Nicosia, and Sperlinga, thousands live in caves, partial or complete. In one of the more prosperous towns of 3,500 households before the war, 2,000 were living in one or two rooms, sharing them with domestic animals. Only 262 households had installations for running water, the other households obtaining their water from faucets scattered throughout the town. Only 1,000 families had privies. Since entire towns were destroyed during the war, housing from many tens of thousands was reduced to the primitive level.

The Sicilian is born into a complex set of family relationships, sanctioned by religion, morals, and customs, and involving duties and obligations which he has not been able to ignore. The most

important of these, those based on the biological ties, are indissoluble. There may be much or little affection for each other among the various members of a family, but no one questions their reciprocal obligations. In fact, among some of the peasants, there exists a vague concept that the individual shares with his mother, brothers, and sisters—and to a lesser degree with his father and relations—part of the substance of which he is made. It is expected that the individual will submerge his own interests to those of his family. For example, it is not unusual, upon the death of the mother, for the oldest daughter to take her place in the family and even forego marriage for the sake of her younger brothers and sisters; or a grown man, married and with children, to refuse a much better post away from the town in order to stay near his mother. Consequently the Sicilian fortunate enough to have a job or own a parcel of land has had to share his meager income with his relatives.

Sicily is a land of some 750 cities, towns, and villages: its countryside is deserted. One looks in vain for farm houses and barns such as one sees everywhere in the United States. The few houses one sees outside the towns are the country homes of the wealthy—generally large establishments occupied part of the year by their owners. Less than 10 per cent of the population actually lives on the farm and this portion is made up largely of caretakers. This is in striking contrast with other regions of Italy. In Emilia, for example, 62 per cent of the population lives on the farms; and in the Marche, 55 per cent. Over one half of the Sicilian towns are located at altitudes ranging from 1,000 to 3,000 feet above sea level. Varying in size from 1,000 to 20,000 inhabitants, they account for 56 per cent of the population. Furthermore, the location of the towns—often on crags and hilltops, once desirable for purposes of defense—today present serious economic and social problems.

Living closely packed in towns, the Sicilian feels constrained to abide by the traditional mores, for he must be constantly on guard lest he commit a public indiscretion and invite censure. Any violation of the social code may bring severe sanctions from the priest, the prospective employer, and the neighbors. Above all nothing must happen to make him lose "face." "Face" is lost if the traditional patterns of family relationships are not followed. One must always make a "bella comparsa" (*i.e.*, a good appearance) in public. The misery of the family must never be revealed. Poverty must be made to appear simulated—the family chooses to live poorly from modesty and prudence. On occasion a certain display of wealth may be necessary: a man must appear at the cafe occasionally and treat his friends to a cup of coffee; on feast days he takes care that he is seen purchasing a pennyworth of sweets for his children.

The Sicilian is taught that the only way to cope with the world is by accommodating himself to it, and one way is to win the sympathetic interest and protection of his superiors. As a result, winning the affection of a superior becomes the index to one's own intrinsic worth. Fond parents do not talk of the achievements of the child but rather of his ability to win the affection of his teacher. The ex-soldier boasts of how much his officer loved him—"like a son." To instill this attitude in the child, training begins early. A boy receives few signs of approval from his father and many of disapproval. He can never do enough, no achievement is sufficient to satisfy his father. If he is successful in school, the father may boast about it to his friends, but at home he will tend to press his child to extract more from the situation than is generally possible. The father is an unapproachable, authoritarian, exacting figure from whom he receives little overt love. Eventually, the child rebels against his father and in the post-war years this rebellion found frequent expression in accusations of avarice and parsimony.

The same situation is reflected in the Sicilian's religious lore. God, the Father, is remote and seems to take little interest in his welfare. God sets up standards of conduct which the individual cannot live up to no matter how he tries. The Sicilian is told to pray to the saints and to practice the Christian virtues. He does so but he receives no tangible benefit. The trouble, he reasons, must be within himself: he is unworthy. The priests, his parents, and his employers are perhaps right after all.

Consequently the Sicilian does many things both because it is better for him to conform and because there may be a chance that some good may come of it. For example, it is the custom to hang a small heart made of red ribbon around the neck of young colts. These are blessed by the priests and are supposed to protect the colt from accidents and to ensure his growing into a fine, strong animal. On being asked if he believes in the effi-

ciency of the amulet the answer may be, "They say it protects the colt," or "it's just a superstitution," or "it's pretty." Pressed further, they would add that conforming to the custom did no harm and if they did not do it they would subject themselves to unnecessary censure. Besides, there might be something in it after all.

The Sicilian, despairing of his lot and skeptical of miracles, employs accommodation not only as an outward demonstration of conformity to avoid censure, but also as an attack on his oppressors. In Sicily, they say, everybody "including the cats" became a fascist, and the first converts were the sociologists—but Fascism was deflated and made impotent. There was an overt show of conformity but no inner conviction. When Fascism collapsed and the Allies re-established democracy, everyone was converted overnight. Democracy brought oratory, promises, and the Cold War. So the peasant greeted the bosses again with "I kiss your hand, excellency" and waited to be given a job as he had waited during Fascism.

The ideal Sicilian world would be one in which there is no government, but the Sicilian knows that there has to be a government in the nature of things, so he accepts and resists any government. As to disputes, he would prefer to settle them personally without the intervention of any government. He lives by and believes in the code of *omertà*. A man must right his own wrongs and since the government is the enemy of all men, he will not betray even his enemy to the government.

The war reduced many Sicilians to destitution, but it did not change the social-economic pattern. The population became larger and the economic resources poorer. It weakened family ties particularly in those cases where the men were away for many years. It did not, however, weaken the duties and responsibilities of the individual. The veteran returned to his family and found himself in the position of having to take on the burdens of supporting a family without the possibility of being able to do so. He may have found that his wife had been able to manage during the war by hiring herself out as a servant or trading in the black market. In Sicily, however, earning a living is the man's responsibility. He could not permit his wife to continue working even though he himself could not find employment. The women on their part, having experienced some independence by earning their own living, have been reluctant to forego it. As a result, the veterans not only have felt inadequate to the situation but, threatened with the loss of their traditional position in the home, have become involved in marital strife. Feeling keenly the humiliation and worries of their menfolk, the women in many parts of Sicily have become more rebellious politically than the men.

In this brief article it is impossible to review all of the tensions which would lead to rebellion in Sicily, nor all of the ways in which the Sicilian has accommodated himself to the post-war situation. Perhaps the picture may be made clearer if we think of the total Sicilian culture as a gas bomb—if the pressure of the gas is increased (economic poverty, inability to make adjustments, psychological tension), or the containing shell is weakened (public authority, social and religious sanctions, accommodation), then there may be an explosion. Obviously, the total cultural situation should be taken into consideration in any plan of aid that might be devised for Sicily to keep it from exploding. One suspects that what applies to Sicily may well apply to other critical areas in the world.

*DIVISION OF MYCOLOGY**

THE ISOLATION AND DIFFERENTIATION OF *MONILIA* AND OTHER FUNGI†‡

By GEORGE H. CHAPMAN§

The name *Monilia* was chosen for the genus *Candida* in the title of this paper not because of any conviction that it is taxonomically tenable but because a large proportion of persons still refer to this genus under that name. Similarly, the author begs the question of "species" because he believes that the work to be described places another aspect on the taxonomy of this fluid genus which may lead to further reclassification of it.

Usual methods for the isolation of fungi depend on the inhibition of bacteria by an antibiotic, which is unstable, and they provide no means for differentiation of the colonies except on the grounds of their morphology. The medium to be described not only inhibits an extreme excess of bacteria but *Candida* and other fungi that grow on the medium produce characteristically colored colonies, some of which also have characteristic morphology. It is prepared as follows:

Neopeptone, Difco	10 grams
Maltose	40 grams
Bacto agar	15 grams
Tergitol-7 (Carbide & Carbon Chemicals)	0.10 ml
Bromcresol purple, 1.0 per cent	2.5 ml
Water	1,000 ml

Ajdust to pH 5.6. Sterilize 10 minutes at 14 ± 1 lb. When cool and ready to pour add:

Potassium tellurite, 1.0 per cent	0.3 ml
2,3,5-triphenyltetrazolium chloride, 1.0 per cent	3.0 ml

Inoculate the surface of the plates and incubate them 48 hours at 37° C. Most other fungi will grow after further incubation. *Endomyces* is among the few that do not grow on the medium.

Candida albicans produces "off-white" colonies about 4 mm in diameter depending on the density of the growth. They are circular, smooth, entire, and convex to pulvinate. Many cultures that had been designated as "*Monilia albicans*" did not give this characteristic appearance, suggesting that true *Candida albicans* may comprise a narrower group of properties than that used to designate the species at present. Other *Candida* produce more highly colored colonies, ranging from orange and tan to lilac, often with discolored surrounding medium. *Saccharomyces* grows in 48 hours and produces colonies somewhat resembling those of *Candida*.

The selective properties of the proposed medium depend on Tergitol-7, which inhibits all bacteria except the coli group, and potassium tellurite, which inhibits the coli group. When the inoculum is heavy, such as in feces, in which the amount used is 1.0 ml of a 1:10 dilution of thick fecal paste, a few colonies of *Escherichia*, Aerobacter or paracoli may grow but they can never be confused with fungal colonies.

The differential properties of the medium depend on the H ion indicator, bromcresol purple,

TABLE 1

Source	*Number of cultures*	*Candida No.*	*found %*
Nasal cavities	214	2	1
Pharynx	152	37	24
Gingivae	11	4	36
Feces	18	6	33

which detects alkaline changes common in most *Candida* (and *Saccharomyces*) but not *C. albicans*, potassium tellurite which may be reduced, and 2,3,5-triphenyl tetrazolium chloride, which is reduced to the red formazan by many fungi[1] and bacteria.

The medium has been used routinely on about 150 persons with chronic diseases. Most of the earlier stool cultures were unsatisfactory because the medium did not contain potassium tellurite; hence the small series reported. In addition, it was found that the inoculum could be increased to a large amount and thus detect *Candida* when it is present in small numbers. *Candida* was very plentiful in gingival cervices but rare in the nares. Each naris was tested separately and the following results were obtained (TABLE 1).

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* A paper entitled "Some Problems Concerning the Dynamics of the Gulf Stream," by Gerhardt Neumann, New York University, was presented at a meeting of the Section of Oceanography and Meteorology on March 25, 1952. No abstract of this paper had been received at the time of publication.

† A paper entitled "Morphogenesis in the Ameboid Slime Molds," by John T. Bonner, Princeton University, was presented at the meeting of the Division of Mycology on March 28, 1952. No abstract of this paper had been received at the time of publication.

‡ This paper was presented at the meeting of the Division of Mycology on March 28, 1952.

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